POWER

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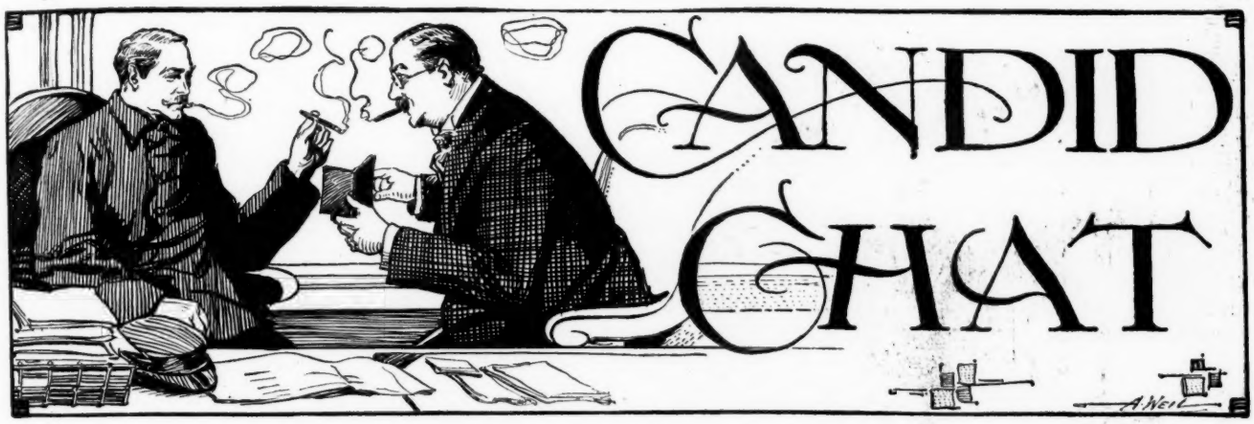


Osgood's Dope Book

When Anderson, our former chief, resigned to take charge of a new industrial plant that was nearing completion on the other side of the river, there naturally was a good bit of speculation as to who would succeed him. I confess that I was tickled when I got the message that Osgood, the manager, wanted to see me in his office.

There was little suspense. As soon as we had our cigars—Osgood's cigars, rather—going well, he quietly informed me that I had been chosen to fill Anderson's shoes. He didn't decorate his announcement with verbal bouquets. He was as matter-of-fact as though he were telling the butcher to cut off three pounds of steak.

I let him know that I was pleased, but I tried not to slop over in doing it. Then I asked him a point-blank question.

"If it isn't a state secret," I said, "I'd like to know just how you came to select me for this job."

"I don't mind telling you," he smiled.

From a pigeonhole he pulled out a notebook bound in red leather, opened it and held it out so that I could see my name at the top of one page, followed by many lines of fine writing.

"I call that my Dope Book," he remarked. "It contains a record of every man in the plant—his disposition, health, habits, strong and weak points, experience, training, home life and everything else that could possibly be of value in determining his fitness for advancement. It has helped me in selecting a good many men for promotion and I keep it more carefully than a schoolgirl does her diary."

I thanked him for the information and went back to my new job. But I couldn't help wondering whether other employers weren't following the same plan and whether many an engineer's failure to get ahead might not be due to certain unfavorable entries in somebody's unsuspected Dope Book.

Mechanical Equipment of a Modern Hotel

It is the purpose in two or three articles to describe the mechanical equipment of a modern hotel plant coming under the charge of the chief engineer and his operating staff. Nothing sensational or revolutionary is found, but taken as a whole it comprises a complete community service station probably with as diversified equipment as may be found anywhere. The reader who is not familiar with this branch of engineering may get an insight into the duties and responsibilities of his fellow engineer.

THE Hotel Pennsylvania, New York City, is the world's largest hostelry. It occupies a ground space 200 by 400 ft., is 19 stories above grade and contains 2200 guest rooms, a large number of living rooms for employees, business offices, dining rooms, grill room, roof garden, swimming pools, turkish baths, etc. The illustrations are for the most part from the actual contractors' blueprints loaned by courtesy of Messrs. Tenney and Ohmes, consulting engineers for the architects, McKim, Mead & White. Sizes or capacities are noted in many instances to add interest. At present there are no boilers in the building, although provision has been made for them if it is found desirable to put them in. Steam and electric power is supplied by contract from the Pennsylvania Railroad Co. Service station at 150 lb. gage pressure through either one or both of two pipe lines, one 12 and the other 8 in. in diameter. The condensate is returned to the boiler house by gravity through either of the return lines, one 5 in. and the other 3½ in. in diameter. The pipe lines follow approximately the plan shown in Fig. 1. The steam passes through separators located as shown in Fig. 2, which is near the point of junction of the Pennsylvania Railroad Co.'s service lines and those of the hotel. The course of the high-pressure steam lines within the building and the various cross-connections, reducing valves and supply branches may be traced on this plan. A careful study of the steam requirements was made based on the actual steam consumption in other hotels, extending over a period of years, so that it is probably the best-analyzed proposition of the day as to heat balance. As a result of this study it was found that much of the machinery could be steam-driven and the exhaust used for other purposes, thereby making the best possible use of the heat in the steam; and as a parting service, all of the condensate is put through a closed heater, in which it gives up more of its heat to the incoming cold water that is to be heated. It was found that during a large part of the heating season more low-pressure steam would be required than would be passed through the steam-driven ammonia and air compressors, pumps, etc.; therefore a 500-kw. direct-connected generator

set has been put in, to be operated as much of the time as the exhaust from it can be utilized—the engine acting as a steam pressure-reducing valve, the generator supplying as much current as it may, to supple-

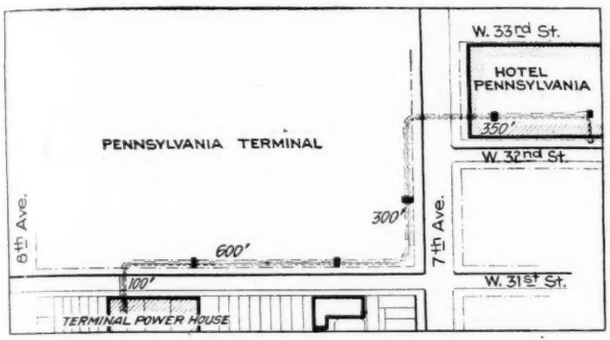


FIG. 1. APPROXIMATE RUN OF SERVICE LINES

ment the service from the service plant. The "heat balance" can in this way be kept almost ideal. There are numerous other steam units, including three horizontal steam-engine-driven double-vertical single-acting ammonia compressors. Each unit is rated at 90 tons' refrigeration. Two of the units operated at a time are expected to take care of the maximum demand, leaving one in reserve. Details of this and other power units will be taken up in connection with their respective sections. The major part of the heating is by direct radiation, of which there is approximately 100,000 sq. ft. of surface. To supply these radiators there are more than 100 pairs of risers (supply and return pipes), totaling about 15 miles of vertical risers and 12 miles of branch piping or radiator connections. The returns are under a moderate vacuum, each radiator having a thermostatic trap at the outlet and a modulated inlet

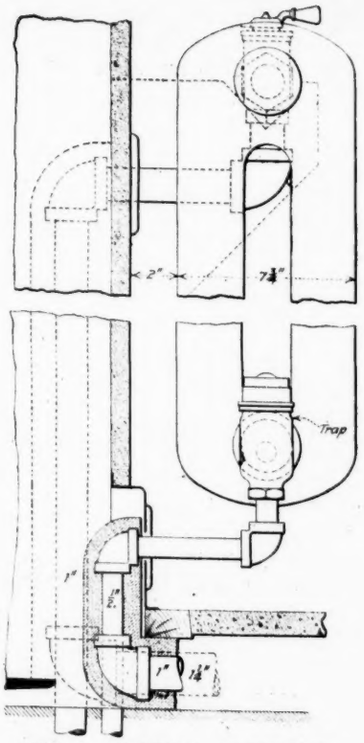


FIG. 3. TYPICAL RADIATOR CONNECTION

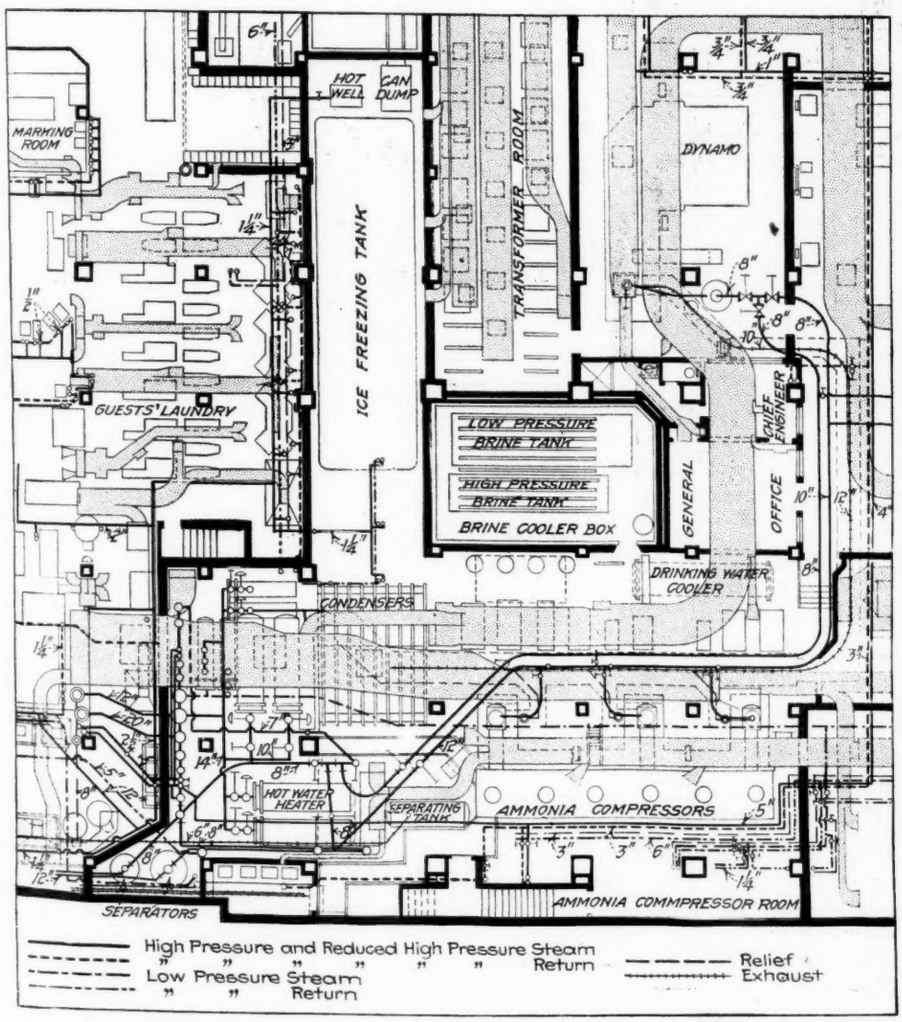


FIG. 2. SUB-BASEMENT PLAN, SHOWING GENERAL LAYOUT

valve. Indirect heating is employed in the roof restaurant. All exposed radiators are suspended on concealed wall brackets, and the pipe connections come through the wall and not the floor; so there is nothing to interfere with carpeting or cleaning. A typical radiator with connections is shown in Fig. 3. All steam risers are provided with expansion loops at the third and ninth floors to allow for expansion and contraction. These loops are made up of two 6- to 7-ft. lengths of pipe joined by two elbows, and a nipple or short piece of pipe. Fig. 4 shows a typical section of the heating risers, giving the pipe size and the amount of radiation supplied at each floor. In a few instances concealed radiators are located beneath the windows and consist of two separately piped sections, a little heat being allowed on the smaller radiator continuously in frosty weather to keep the window glass clear. Ventilation is accomplished by motor-driven fans, of which there are 9 now in place on the air sup-

ply and provision for 4 others later, and 16 exhaust fans now in, and ducts for 2 more if needed. There are 9 other fans in connection with the air washers, heat regulation, etc. The air-supply fan motors average about 25 hp. each, or a total of 227 hp.; the exhaust-fan motors about 27 hp. each, or a total of 428 hp. The grand total for the fan motors enumerated is no less

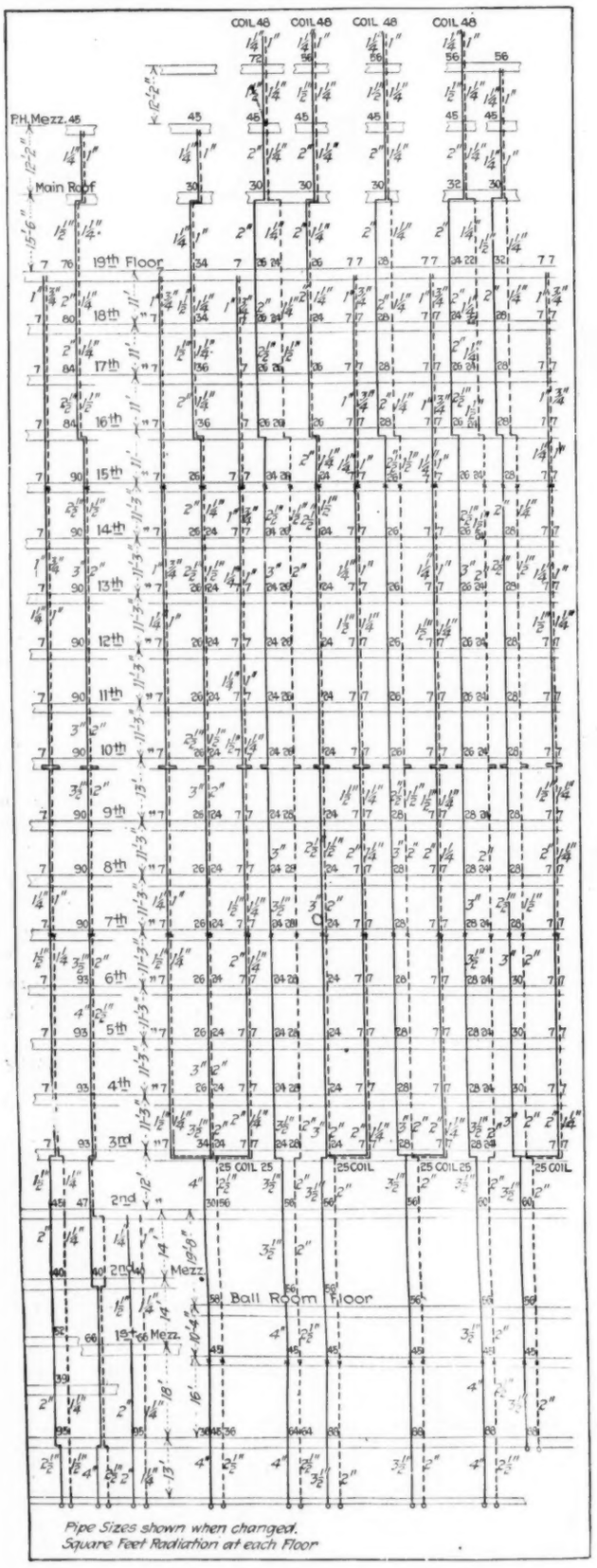


FIG. 4. SECTION OF RISER ELEVATION PLAN

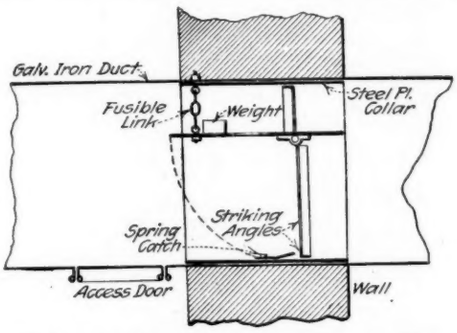


FIG. 5. SELF-CLOSING FIRE DAMPER

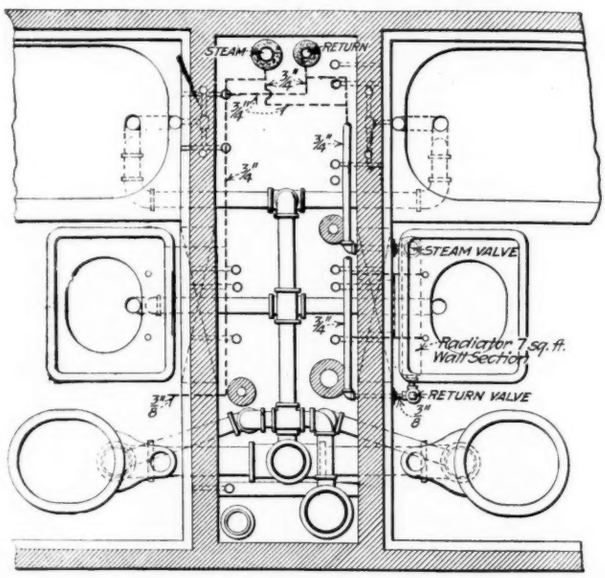


FIG. 6. PIPING IN SHAFTS BETWEEN BATHROOMS

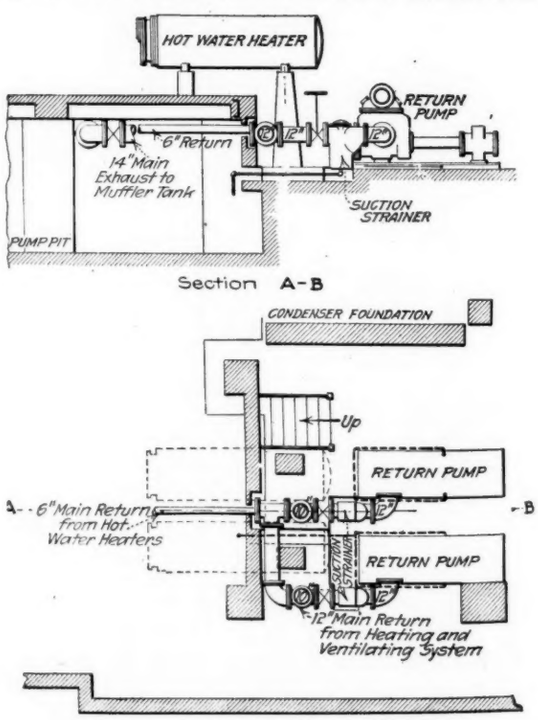


FIG. 7. RETURN-PUMP CONNECTIONS

than 700 hp. Outside air is taken in at the level of the third floor on the Thirty-third Street side of the building and is conducted downward to the air washers and fans through three ducts, totaling 300 sq.ft. area. The pipe shafts located between the bathrooms of adjoining rooms also serve as exhaust air ducts but vent ducts are kept free of all piping wherever possible with this exception. These shafts are approximately 2 by 7 ft. and contain the hot- and cold-water supply pipes, the refrigerated drinking-water pipe and the waste pipes from the bath tub, toilet and wash basin and the bathroom radiator piping, etc., as shown in Fig. 6. The register shown near the ceiling is for the bathroom ventilation. Each duct main register is, as required by the city fire regulations, fitted with a self-closing damper constructed as shown in Fig. 5, in which a fusible link that will melt at a low temperature is employed to hold the damper open normally; but in case of a slight increase in temperature, the link will fuse and allow the damper to close and prevent the spread of fire. A small door for entrance to the shaft is provided just above the wash basin. It will be observed by anyone who has had experience with pipe work that there is no great amount of excess room for workmen to make repairs when they become necessary. Many of the transfer spaces where piping, ducts, etc., are carried horizontally between the hung ceiling and the true ceiling present a surprising and intricate network of piping.

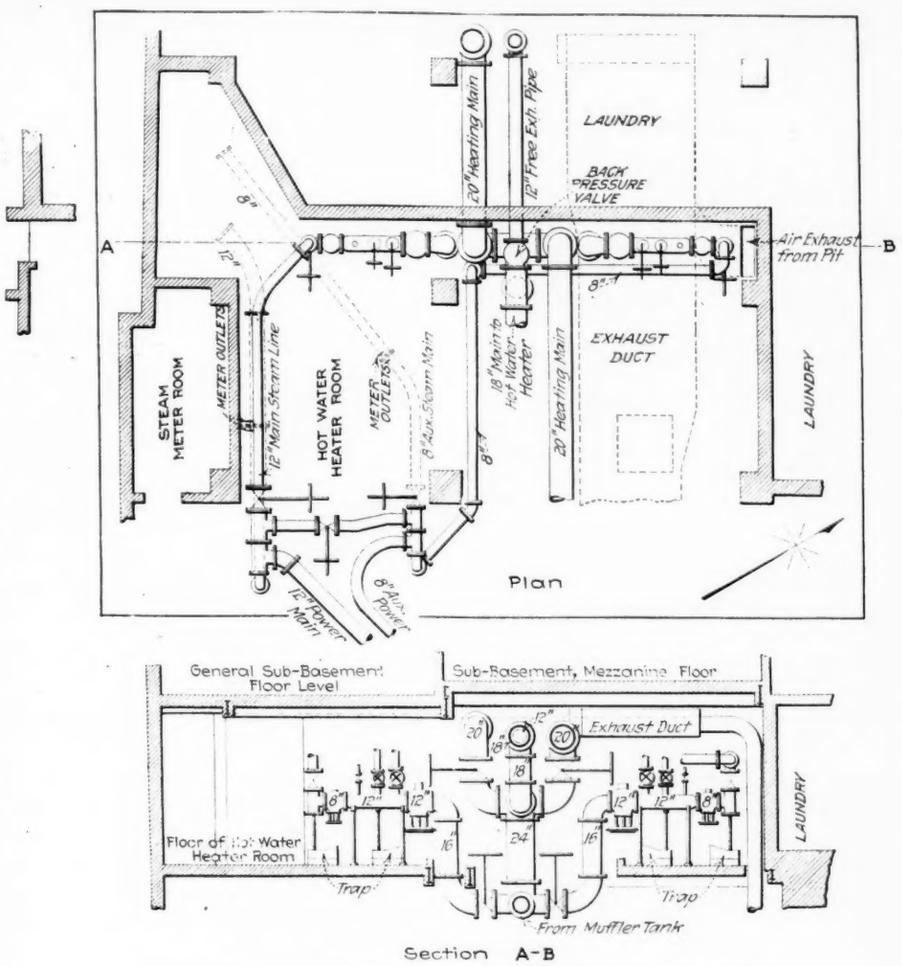


FIG. 8. PLAN AND ELEVATION OF PART OF HEATING MAINS

The returns from the heating system are connected to vacuum pumps in duplicate. The connections and pipe sizes are shown in Figs. 7 and 8. Fig. 9 is a floor plan of the fifth to fifteenth floors, those below being slightly modified by the dining and other large public rooms.

A section to follow will deal with the refrigerating plant and distributing piping and another with the electric and telephone systems.

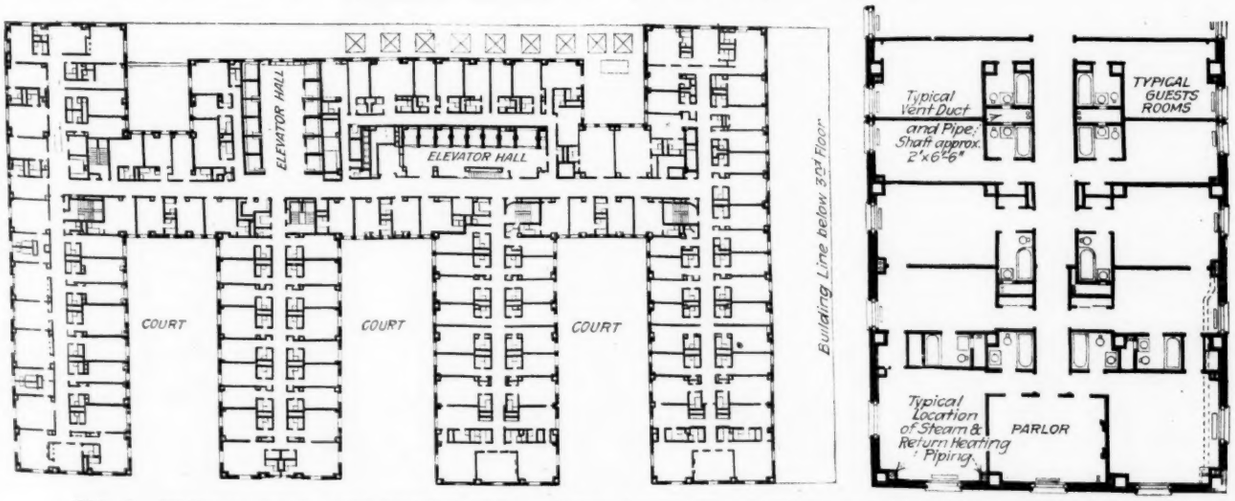


FIG. 9. TYPICAL PLAN AND ROOM ARRANGEMENT OF UPPER FLOORS OF THE HOTEL PENNSYLVANIA

Meeting Emergencies in Refrigerating Plants

By E. W. MILLER

Vibration caused by a runaway engine allowed the gasket in the ammonia discharge line to blow out. If the men had abandoned the runaway because of the fumes, the engine and other machinery would have been demolished. The assistant engineer's quick wit saved the situation. With the day load coming on apace and only one small engine loaded, the voltmeter refused to register when the engineer was about to parallel the large unit. But he devised a means and "shot" the machine in without injury and in time to prevent blowing the circuit-breaker on the small unit. These and other situations, such as you have found yourself in, are told about by the author.

TO HEAR some of the Old Timers talk, one would be held to believe that the days of rapid-fire thinking and the necessity for quick action were things of the past. In the good old days these fellows solved a half-dozen hair-raising problems in a day, and some of them evidently lay awake nights figuring out some new wrinkle to shut the plant down and make a record for rectifying the trouble. However, the youngsters of today might be able to show them a thing or two that would leave the veterans scratching their heads.

Not long ago in a large combined power and refrigerating plant the crew were having some trouble with the governor on one of the power engines, and it took the combined efforts of a man at the switchboard and an oiler at the throttle of the engine to keep the engine from racing or taking the entire load and eventually tripping the circuit-breaker and shutting down the plant. One of the assistant engineers was in the meantime trying to find out what was wrong with the governor and rectify it if possible.

A 200-ton Wolf ammonia compressor was running next to the contrary power unit. Between the two was a floor drain which had become plugged, and two men with a hose were trying to clear it by pumping into it water at a high pressure. Without warning, part of the gasket in a flange in the discharge line of the ammonia compressor, just above the floor, blew out. In a few moments the place would have been so filled with ammonia fumes that it would have been impossible to stay there, so everybody headed for the doors.

The Quick-Witted Assistant Engineer Saves the Day

The assistant, who was tinkering with the governor of the outlaw power engine took in the situation at a glance and realized that if left to itself the power would be off in a few seconds. Indeed one or more of the engines might be wrecked.

Yelling to the oiler and the man at the switchboard to stick to their places and watch the engine, he grabbed the hose, which had been abandoned the moment the gasket let go, and turned the full stream of water on the leak. At the same time he yelled to another oiler who was heading for the door to shut down the ammonia compressor.

Another man was sent pell mell up on the roof to shut off the valve in the discharge line at the condenser. The suction valve on the machine was shut before it stopped, the bypass valves were opened and the machine kept turning slowly until the head-pressure gage showed zero. This required but a few minutes, as the discharge check valve held nearly tight and a few revolutions of the machine pulled the gas out of the line up to this valve and brought the pressure down to atmospheric. In the meantime the stream of water directed at the leak absorbed much of the fumes. As soon as the pressure on the line came down to zero, a rag was tied around the leak and a stream of water kept gently playing over it. The bypass valve around the discharge check valve was slowly opened until the head-pressure gage showed a rise in pressure. In this manner the discharge line back to the condenser was pumped down to atmospheric pressure. When this was done the stream of water was shut off and the joint plastered with some boiler coating, after which a high vacuum was pumped on the line. This cleared it and allowed steamfitters to replace the gasket.

The quick-wittedness of the assistant in using the water hose to kill the ammonia fumes was probably all that saved the power equipment from demolition. The men stuck to their posts, and when the leak was stopped it was found that a piece of waste had got caught in the governor.

Voltmeter Refuses To Register

When getting ready to parallel a large power unit one morning, it was found that the voltmeter refused to register, when switched to this unit. The engineers lost considerable time trying to locate the trouble and finally discovered that one of the connections was broken. No wire was at hand to make a new connection, and besides it was in an awkward location where it would probably take half an hour to rig up even a temporary connection.

In a few minutes the load would be coming by leaps and bounds and the smaller unit, which was just able to take care of the regular night load, was laboring to keep up normal speed, while the brushes on the commutator were spitting fire and letting out an unearthly squeal every once in a while.

The engineer spied a lamp cord on the floor, and yanking out his jackknife, he cut this off a few feet back from the lamp and skinned the ends of the two wires, making an improvised test lamp. Testing across the terminals of the machine, he found that the light came up glaringly bright. Readjusting the rheostat to about the point where he normally had it when cutting in this unit and having one of the men slow it down with the throttle, he finally reduced the voltage to a point where it was slightly more brilliant than when placed across the bus terminals.

Stationing a man at each throttle with orders to the one at the larger unit to open up quite lively if he managed to cut it in safely, he slammed in the switch.

The larger machine took more than a fair share of the load, but no serious difficulty was experienced. Two minutes later the load had climbed up to normal for the larger machine. If it had not been cut in by this time, the other machine would certainly have tripped the circuit-breaker and left the plant in darkness.

The Equalizing Switch Was Broken

In another plant two badly overloaded compound-wound generating units were carrying the load. A gang of men were installing an additional unit alongside the other two and were bringing in one of the heavy parts with the crane. It was coming along quite lively, and when passing one of the pedestals for the equalizing switch in front of one of the units, it made an unexpected swing and knocked this clear off, breaking the connections.

The two machines never got along very well together even with the equalizing switches in, and the moment the switch was broken one of the units started to take the load while the other began to take things easy.

The switchboard was some distance from the engines, and the man in charge of them saw that he had a small chance of getting to the board and adjusting the rheostats before the one machine would trip out. The engineer saved the day, however, by an ingenious trick. Grabbing the two leads to the broken switch, he laid the two bare ends on the cement floor and dropped a heavy casting on them. This renewed the equalizing connection, and the machines promptly and with good grace took up their equal shares of the load.

An Oiler Shows Commendable Presence of Mind

While attending to the oiling of his machines on the first deck of a 250-ton York vertical machine, the oiler in a large refrigerating plant showed rare presence of mind that would do credit to a more experienced man. While up there the stuffing-box blew out a cloud of ammonia, at suction pressure. The pressure forced the fumes directly downward, and for the moment the oiler was above them and out of danger.

Noticing that there was a window even with the top deck, leading out on an adjoining roof, he yelled to the engineer at the machine to shut it down, which he did and ducked. The oiler gave the suction valve a spin that sent it nearly shut and a few more turns were sufficient to shut it tight. He then raced to the upper deck and did likewise to the discharge valve. By this time breathing was getting difficult and the tears in his eyes blinded him, but he found his way out through the window onto the roof. The ammonia loss was not noticeable, owing to his quick action. A month later the same thing happened an another machine on the night shift and over 1500 lb. of ammonia was lost. During a hot spell one summer an ammonia suction line sprang a leak in one of the rooms where a large number of people were working. In a short time the fumes were too strong for them to remain in there with the windows shut. If the windows had been opened the temperature would have been too high for the product handled, so it looked as if the department and possibly a large number of the others would have to be shut down until the leak was repaired. The plant was running night and day on rush orders. Repairing the leak would require the better part of a day, as it was in an awkward position and two other joints would have to be removed before it could be reached.

How the Engineer Stopped the Leak Without a Shutdown

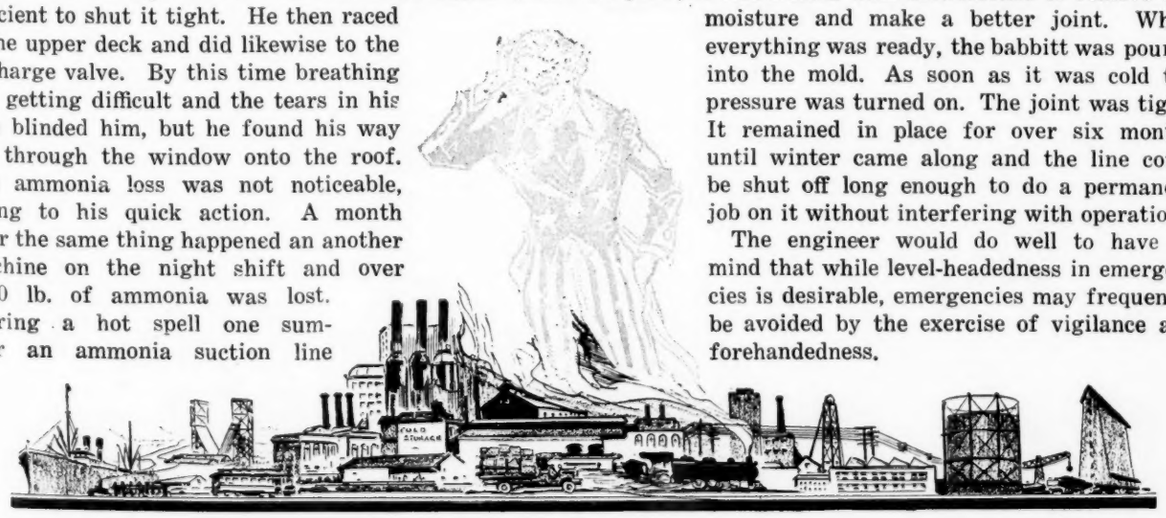
The engineer solved the problem. First he wrapped some burlap around the joint and rigged up a hose to run a small stream of water over it and down into a barrel underneath. This absorbed the ammonia fumes as the leak was not very bad, but only a little is sufficient to make the air unbearable in a closed room. A man was stationed to carry the water away from the barrel as it filled up. This allowed the men to go to work again.

He next found a pipe slightly larger in diameter than that of the flange of the joint where the leak was located. This was sawed in halves. Two boards had holes cut in them of the same diameter as the pipe and these were also cut in halves. When he was ready to go to work, two large ladles of babbitt were melted on a forge near the room where the work was to be done. The line was pumped down until the leak stopped and the machine was run slowly to hold it just at this point.

The two halves of the pipe were then placed over the leaky joint and clamped in place. The two boards were butted up to hold the split pipe and the two halves of each board nailed together with crosspieces. By means of ropes they were then pulled tightly against the ends of the pipe. A plank was placed across two stepladders for the pipe to rest on and the whole banked up with fireclay. A hole had been drilled at each end of the split pipe, one for pouring the babbitt and the other for an air vent.

Just before the split piece of pipe was placed over the joint, it was heated with blowtorches to remove the moisture and make a better joint. When everything was ready, the babbitt was poured into the mold. As soon as it was cold the pressure was turned on. The joint was tight. It remained in place for over six months until winter came along and the line could be shut off long enough to do a permanent job on it without interfering with operations.

The engineer would do well to have in mind that while level-headedness in emergencies is desirable, emergencies may frequently be avoided by the exercise of vigilance and forehandedness.



Revision of A. S. M. E. Boiler Code

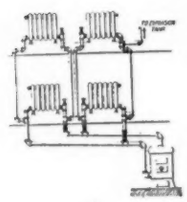
Parts I and II, Section II

THIS PORTION of the A. S. M. E. revised boiler code relates to revisions in Part I, Section II, Heating and Hot-Water Supply Boilers; Part II, Existing Installations, and the Appendix. It does not apply to economizers or to feed-water heaters.

UNDER the heading, "Maximum Allowable Working Pressure" a number of important changes have been made in this section of the Code. Quite extensive additions have been made to Par. 338. These additions indicate that the pressure to be allowed on a boiler used on a closed system, either for hot-water heating or hot-water supply, shall be one-half that allowed on the same boiler if operating on an open system. This paragraph also defines what is meant by open and closed systems (see A).

The wording of Par. 339 has been changed, apparently with the object of using fewer words and more clearly expressing the intent of the original paragraph.

Par. 345, which relates to the subject of washout holes, has been changed so that its provisions apply equally to steam-heating boilers and boilers used for hot-water heating, as well as to hot-water supply boilers.



A

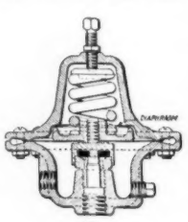
A change made in Par. 349 makes it clear that its provisions shall apply to both hot-water heating and hot-water supply boilers. This paragraph also indicates that water-relief valves that may be used on such boilers shall be of the diaphragm-operating type. It is further specified that such valves shall be so designed that the diaphragm will fail at a pressure not in excess of 50 per cent. above the allowed pressure, in case the valve fails to operate (see B). Not allowed (see C).

The later portion of old Par. 349, which related to the discharge connections from water-relief valves, has been made Par. 350 in the new Code. This rule in regard to water-relief valves for hot-water boilers built for maximum allowable pressures in excess of 30 lb. pressure, as given in Par. 350 in the old Code, has been removed.

The permissible sizes for safety valves and water-relief valves, as specified in Par. 351, have been changed. The limiting sizes for the range, 1 to 4½ in., as given in the old Code, now refer only to safety valves. Water-relief valves may be ¾ to 2 in. in size.

In Par. 352 duplex valves have been added, so as to make it clear that this type of valve is allowed (see D).

A change has been made in the requirements for the lifting gear for safety valves, as given in Par. 356. This requires that such gear shall be capable of lifting the valve ⅛ in. from its seat instead of one-tenth the nominal diameter of the valve as required by the old Code. This change is the same as made for safety valves for power boilers.



B

The capacity required for safety valves for heating boilers, for both steam and water heating, as given in Par. 358, have been changed. The actual amount of capacity for the safety valves for steam-heating boilers has not been changed, but a new table for determining such capacity has been placed in the Code. The values for the evaporation per square foot of grate surface, as used in this new table more nearly meet the conditions found in heating work. A new table has been added, Table 9A, to show the requirements for capacity of water-relief valves. The formula in this paragraph, 358, has been changed so that W now represents the weight of water evaporated per square foot of grate per hour instead of per second, as formerly.

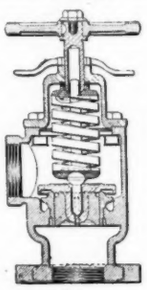
An addition to Par. 360 provides for the determination of the capacity required for a relief valve when placed on a heater heated with steam.

Changes made in Par. 361, in regard to connections for steam-pressure gages, specify that if the gage is located more than 5 ft. from the boiler, the connecting pipe, if less than 1-in. pipe size, shall be of brass, copper or bronze composition. Where the distance to the gage is less than 5 ft., the connecting pipe, if less than ½-in. pipe size, must be of brass, copper or bronze composition.

Similar changes to those made in Par. 360 have been made in Par. 361, relative to pressure and altitude gages for hot-water boilers.

An addition to Par. 363 requires that a temperature regulator must be used in connection with all hot-water heating systems where the pressure exceeds 30 lb. and also on all closed systems, irrespective of the working pressure. Such regulators must keep the temperature of the water from rising above 200 deg. F.

Extensive changes have been made in Par. 374. The first change is in regard to the pressure to be allowed on a cast-iron boiler used for hot-water heating or hot-water supply; the old Code gave no limit to the pressure that might be used on such a boiler, provided it satisfactorily withstood a test of 2½ times the working pressure. The new Code limits the pressure to be allowed on cast-iron boilers to 160 lb. It is further provided that boilers intended for use on closed systems must be tested to twice the pressure required under the same conditions for boilers to be operated on open systems. Field tests, equal to the shop test, must be applied to all boilers to be operated on open systems at pressures in excess of 50 lb. or on closed systems in excess of 25 lb. These tests are 2½ and 5 times the working pressure, for open and closed systems respectively.

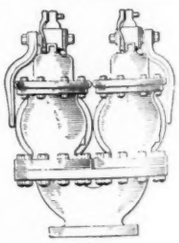


C

Changes have been made in Par. 377 to provide for proper stamping to indicate the pressures for which a boiler is designed and constructed for use in connection with either a closed or open system. It also provides that heating boilers, built under the Code rules, shall be stamped "A. S. M. E. Standard."

Part II—Existing Installations

Few changes have been made in the rules for boilers already installed. The most important change noted in this section is in relation to Par. 384, which deals with the condemnation of boilers in which a lap-seam crack has been discovered. The wording of the old paragraph was as follows: "No pressure shall be allowed on a boiler on which a crack is discovered along the longitudinal riveted joint." As will be noted, this wording did not define any particular class of crack. It is clear, from the revised wording, that the kind of crack that was meant was what is commonly known as a "lap-seam crack." The original wording would have required the condemnation of a boiler if any other kind of a crack appeared at the longitudinal seam. The revised wording of Par. 384 makes it clear as to the kind of crack that is referred to as well as stating definitely that the rule is to apply to butt-strap constructions as well as to lap seams (see E).



D

A change in Par. 402, which deals with the arrangement of blowoff connections, adds bronze and brass as materials allowed for the fittings that may be used on such connections. A new sentence has been added to this paragraph, specifying that in case of replacement of the fit-

tings of pipes on blowoff connections, the installation shall be in accordance with the rules for new construction.

Old Par. 409 has been placed with Par. 408 and an entirely new Par. 409 placed in the Code. The subject of this new paragraph is repairs. It specifies that when repairs are to be made that will affect the safety of a boiler, a properly qualified inspector must be consulted in regard to them.

Appendix

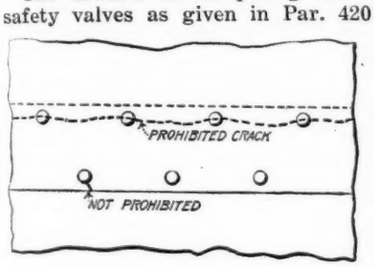
A number of changes have been made in the Appendix to the Code. Par. 416, which in the original Code consisted of two illustrations and the detailed instructions for calculating the efficiency of a quintuple-riveted joint, has been removed. This was no doubt a good move to save space, the quintuple-riveted joint not being adapted to boiler work.

The numbers of all paragraphs from 417 to 427 inclusive, in the old Code, have been reduced by one, a new paragraph, No. 427, being placed in the new Code and it will be referred to later.

The caption for Table XIV, which gives the net area on the segment of a head to be stayed, has been changed to indicate that the values given in this table apply only where *d*, as given in Pars. 214 and 217, is equal to 3 inches.

A new figure, 32, has been added to the appendix, illustrating various applications of Par. 205 and 206 to the staying of boilers.

The method of computing the discharge capacity for safety valves as given in Par. 420 (Par. 421 in the old Code) has been materially changed in wording. The results obtained by the use of the rules given in this paragraph are the same as in the old Code. However, the present form in which the information is given is more easily understood. There has been added a calculation for determining the discharge from a safety valve with a seat beveled at any angle. There has also been added formulas giving the weight of steam that may be handled by a valve in an hour's time.



E

The examples given in Pars. 422, 423, 424 and 425 (new numbers) have been changed so as to conform with the changes made in Par. 420.

The table giving the discharge capacities for safety valves, which in the old Code was known as Table 8 and was placed in the body of the Code in connection with Par. 274, has now been placed in the Appendix and numbered 15.

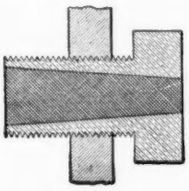
The illustrations that accompany Tables 16 and 17 (new numbers) and which were formerly known as Fig. 30, are now Fig. 31.

The new Par. 427, which has already been referred to, deals with the requirements that must be met in the construction of any automatic water gage that may be used under the Code rules. It is doubtful if any of the attachments of this kind that are now on the market will meet the requirements.

An addition has been made to Par. 428 dealing with the question of filling to be used with fusible plugs. This addition requires that the filling must be renewed once each year. This is an excellent requirement for fusible plugs if they are to be expected to operate properly (see F).

In giving the proper location for fusible plugs, in Par. 430, a new Section u has been inserted and the former Section u has become v. This new section deals with the proper water level in fire-engine boilers.

More than two pages of new material have been inserted in the Code at the end of the Appendix. This consists of recommendations in regard to repairs that may be made to boilers by the autogenous process of welding. These recommendations are the same as the rules of the Board of Supervising Inspectors given in the Steamboat-Inspection service rules for the use of this form of welding. The recommendations do not appear to conflict with the new portion of Par. 186, which deals with the subject of autogenous welding.


F

A manufacturers' data report form has been made a part of the Appendix. This form is intended to be used for boilers built under the Code rules.

The changes made in this edition of the Code appear to have considerably improved this set of boiler rules. The clearing up of a number of points that were in doubt as to the application of the rules as expressed in the old Code will be welcomed both by the manufacturers of boilers and by the inspectors who must see if the rules are lived up to.

Automatic Substation Development

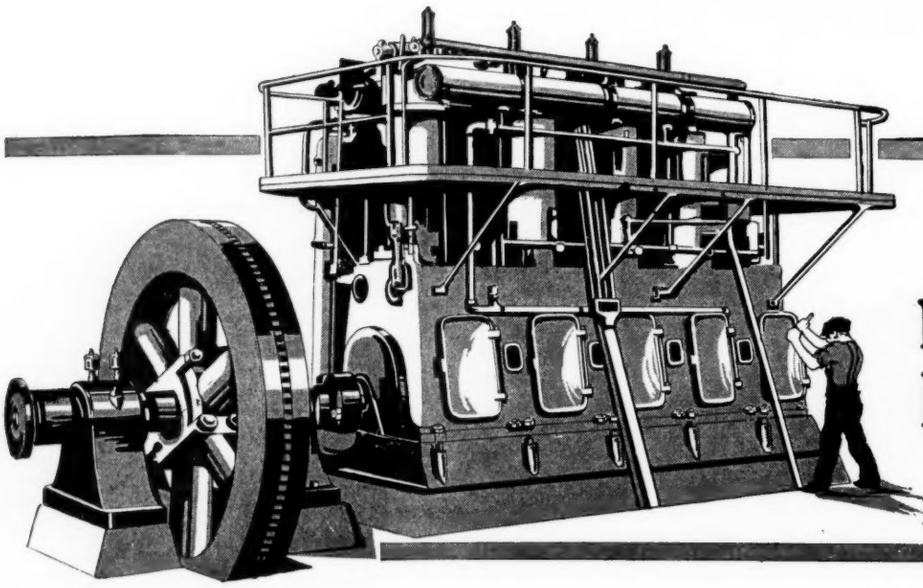
In 1912 the first substation to be controlled without an operator in the station was put into service on the Detroit Edison Co.'s system and consisted of a 500-kw. rotary converter connected to the City of Detroit's lighting system. This machine was controlled entirely by the operator in another station about a mile away. Although this station was not automatically but remotely controlled, it was nevertheless the forerunner of the automatic power plant and substation of today, the latter of which is coming into use with great rapidity.

In 1917 there was put into service in the State of Iowa a 1500-kw. automatically controlled hydro-electric power plant consisting of three 500-kw. two-phase 60-cycle 2300-volt alternators controlled through float switches by the water level in the forebay, as described in *Power*, Dec. 11, 1917. How fast automatically controlled substations are coming into use is indicated by the fact that one electric manufacturing company in this country has built and put into operation 26 such station equipments and has 30 others under construction. These stations are both rotary-converter and synchronous-motor, direct-current generator sets. Some of the motor-generator sets are to supply 1500-volt direct-current.

From the foregoing the possibilities of an automatically controlled system of power plants and substations with the machines cutting in and out automatically to meet the power demands do not look to be so much of a wild dream after all.

American-Built Locomotives Shipped to France

Shipment of more than 400 American-built locomotives weighing each 73 tons and assembled all but the smokestack and tender, so they could move away under their own steam within six hours after arriving in France, is among the accomplishments of the United States army transport service. This number was in addition to 1200 which were shipped in sections—nine to a locomotive—packed in cases. Ships used to transport these locomotives complete, were of special type, with three holds. Into each of the three holds was placed 12 locomotives—36 to a ship. The time consumed in the movement of the locomotive from the builders to the base of action behind the battle line was less than 12 days.



Talks on DIESEL Engines

by L. H. Morrison

VII—The men show considerable interest in the construction of pistons and J. R. explains the causes of piston troubles and methods of overcoming them.

"WHEN the meeting broke up last Thursday evening," Woods remarked to the chief, "you were talking about water-cooled pistons. What's your opinion of them, anyway? I visited the Syracuse plant a couple of months ago and they had just cracked two water-cooled pistons."

J. R. knocked the ashes from the end of his cigar.

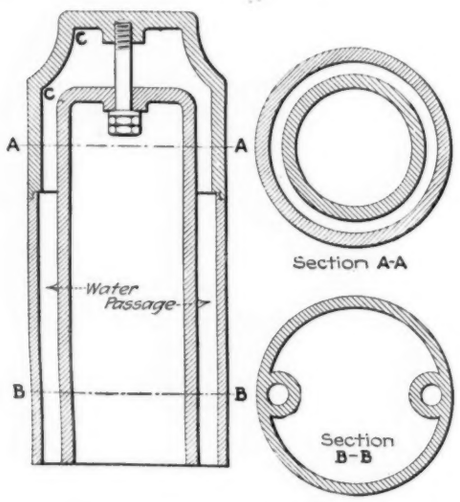


FIG. 1. PISTON LIABLE TO FORMATION OF STEAM POCKETS

"Whenever the cylinder diameter gets so big that the piston head takes up more heat than it can give up to the cylinder walls, water cooling is necessary. We have engines here with 18-in. water-cooled pistons, but I doubt whether water cooling is necessary until the pistons are larger than 20 in. Of course, a good bit depends on the speed. You can easily see that a high-speed engine might require water cooling where a slow-speed engine of the same bore would not need it. On the other hand, water cooling is more successful on slow-speed engines. At speeds of more than 200 r.p.m., the check valves in the water passages do not close quickly enough, and there is always danger that the engine isn't getting the water at all. In an inclosed engine you've got to keep close watch on the water piping.

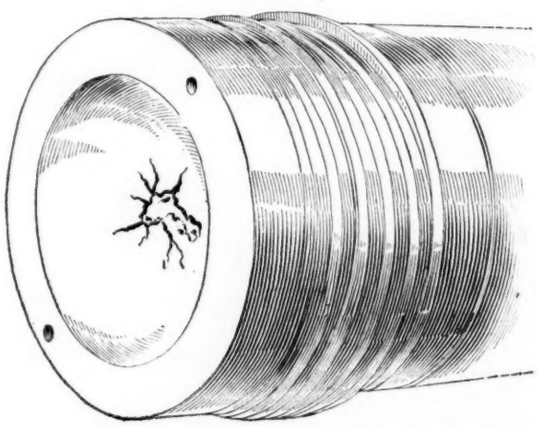


FIG. 2. PISTON CRACKED BY CARBON DEPOSITS

I know that in plants where we have water-cooled pistons, we've had a lot of trouble with leaky water connections. The water will creep into the big-end bearings and cause them to heat up.

"As for fractured water-cooled pistons," continued the chief, "I recall that the outfit you refer to is a horizontal two-cycle engine with the exhaust ports uncovered by the piston, as in Fig. 1. In this engine the circulation of the water depends on the pumping action of the piston. The exhaust gases, as they pass along the bottom of the piston head into the exhaust port, give up a great amount of heat to this part of the piston head. The heat distribution over the piston head is evidently very uneven. If

At the next meeting the various causes of cracked piston heads will be discussed, and Egan will tell a story with a dramatic ending

the water circulation is not very rapid, there is a tendency for steam pockets to form at the point I mark *C*. So, if the check valves leak, the steam pressure often blows the water back through the inlet telescopic piping until the pressure is relieved. The water then resumes its proper flow, and we have comparatively cold water striking a very hot surface. Is there any wonder that you often hear of this type of piston fracturing? The two-cycle feature in the Diesel engine demands piston water-cooling, and if the piping and valves are not kept absolutely tight, the water causes fractures."

His cigar had gone out during this long speech, and he paused to relight it before he resumed his discussion of piston fractures.

"There is one all-important precaution to be taken where engines with water-cooled pistons are used," he said."

"What is that?" asked Woods.

"Well, boys, I've mentioned that leaky water piping is a common occurrence; also that this water got into the lubricating oil. Now, if the water is not removed, the entire oiling system will soon be charged with a water and oil mixture that makes a poor lubricant, especially for a Diesel engine. Therefore I say that in such installations, this oil should be passed through a steam-coil heater to boil out the water. Some depend on a filter to refine the oil. The ordinary filter will remove grit and metallic particles, but the temperature is never high enough to get rid of water."

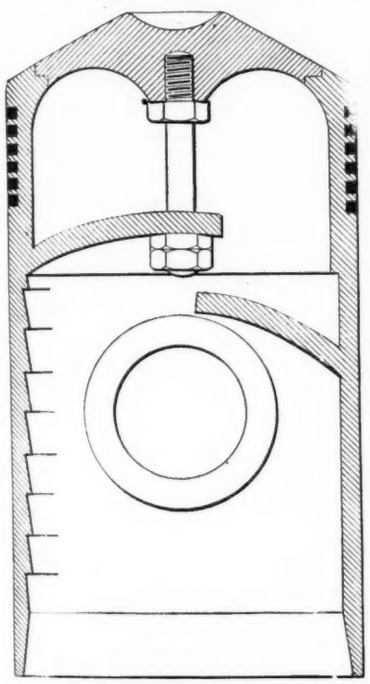


FIG. 3. PISTON BAFFLED FOR COOLING

"Well, chief," asked the ever-curious Woods, "what causes piston heads to crack even when they have strong ribs?"

"Often the core used in molding the piston is green and when the iron is run the surfaces of the ribs are chilled and very small cracks are started. These may develop into serious fractures when the engine is put into service. However, I suspect you mean those cracks which show on the face of the piston. These are usually due to carbon deposits. As you probably know, when the oil is thrown from the piston pin onto the hot piston head, a hard carbon deposit forms, and it is a poor conductor of heat. The piston head is unable to rid itself of the heat absorbed and starts to expand. Since it is strongly ribbed, it can't increase the radius of curvature of the concave portion. As a relief it sort of swells up in a ridge. When the engine stops, the metal contracts again and of course fractures develop in the readjustment of the metal."

He opened his loose-leaf book and took out a page showing Fig. 2.

"I happen to have a clipping showing a cracked piston," he said. "From the photo I would guess that carbon deposit was the cause of the trouble. In such cases the best remedy is to drill holes about $\frac{3}{16}$ to $\frac{1}{4}$ in. in diameter all along the fracture, spaced about $\frac{1}{16}$ in.

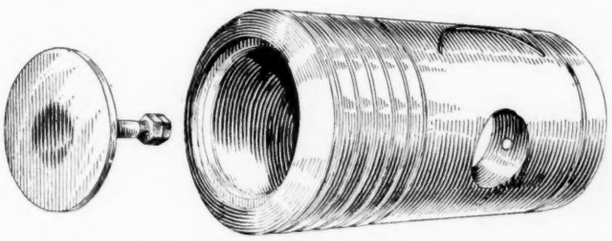


FIG. 4. BUILT-UP PISTON, SECTION OF WHICH IS SHOWN IN FIG. 3

apart. After tapping these holes, screw in copper plugs and cut them off even with the surface. Then drill and tap a second set of holes between the copper plugs, and, after you insert this second row of $\frac{3}{16}$ in. plugs, peen the entire row. This lacing can be done very neatly and will prevent any blowing through the fracture and at the same time will keep the crack from extending. One advantage of the water-cooled piston is that the water cavity prevents the oil deposits from settling on the hot head."

"If that is true," Woods ventured, "why don't the builders make a false head or a partition to keep the oil away?"

"The objection, Woods, is the difficulty of cleaning the head in case the oil should get by the partition. Another thing you should bear in mind is that the air currents set up by the moving piston help to a considerable degree in cooling the piston. A partition would destroy this effect.

"However," continued Egan, "a builder of horizontal engines has used the baffle idea in his engine, as shown

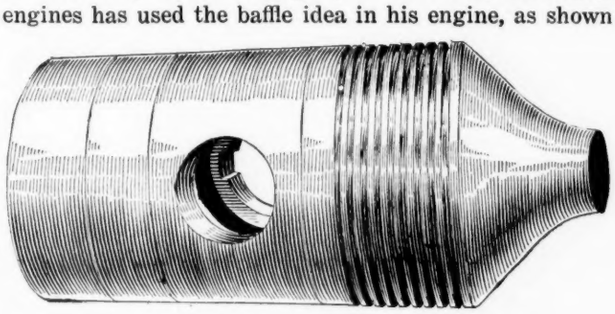


FIG. 5. PISTON FOR HORIZONTAL ENGINE

in Fig. 3. The baffling in this case is in two parts, to allow the air to partly cool the head. Here's another view of this piston"—he showed them an illustration similar to that in Fig. 4.

"What's the idea of the manhole plate in the piston head?" inquired Kelly.

J. R. indulged in a hearty laugh before he attempted to reply to the question.

"That isn't a boiler, Kelly. It's a piston. The thing you call a manhole plate is a removable piston head. This feature is new but successful. It has been found that the pistons of horizontal engines are subject to distortion, which is not usual in the vertical type. This is due probably to the weight of the heavy piston being

at all times on the bottom, which might tend to flatten the piston.

"Now, if the piston is made as snug as in the vertical engine, the expansion of the head causes further distortion and usually the piston will stick. We could obviate this by making the clearance between walls greater, but in so doing we would lose the compression. If the head could be made of a material that did not expand under heat, the distortion would not occur. Consequently, the head is made of a nickel-steel alloy which has a low coefficient of expansion. I do know that piston sticking was very common in one make of horizontal engine until alloy-steel heads were used."

"If a little bit is good, a whole lot ought to be better," said Kelly. "So why not make the whole piston of nickel?"

"Too expensive," Egan answered. "Besides, it's too hard for a rubbing surface. The best material for pistons is good gray cast iron. It machines easily, polishes well and maintains a glass-like surface. Pistons should always be made of a softer iron than the cylinder liner. If you ever have a piston made at a machine shop, in-

CYLINDER WEAR

POSITION	A	B	C	D
RIGHT ANGLES TO PISTON PIN	16.270	16.257	16.252	16.243
PARALLEL TO PISTON PIN	16.279	16.258	16.255	16.243

Note: Piston is 16.23" in Diam. and 32" long, with Six Ring Grooves $\frac{1}{2}$" wide and $\frac{3}{16}$" deep

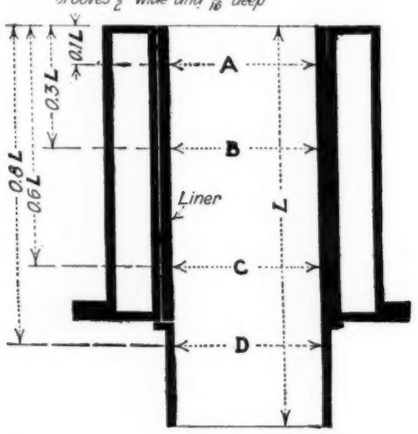


FIG. 6. MEASUREMENTS FOR FINDING WEAR OF CYLINDER

sist that it be cast from iron having a small amount of scrap in it.

"Another example of horizontal engine piston is shown in Fig. 5. Here the manufacturer allows for the expansion by making the head in the shape of the frustum of a cone."

Egan unfolded a blueprint and smoothed it out on the table, disclosing a drawing like that in Fig. 6.

"The Diesel superintendent left this last week," he said, "with orders that we were to take the indicated measurements every time we pulled a piston. You see, two measurements of the cylinder diameter are taken—one parallel with the piston pin and one at right angles to it—at each of the four points indicated. The figures in the table at the top are the actual measurements taken from one of the company's engines. This looks like a good scheme to follow, for it shows the wear that takes place."

Woods was ready with a question.

"How often should pistons be pulled?" he asked.

"If there's no pounding or loss of compression, about once every four months will do. That's our rule here, and I've noticed that if we wait much longer the piston rings are badly gummed up. When a piston is pulled, it should be cleaned thoroughly with kerosene, all soot scraped from the top, all carbonized oil removed from the interior and all rings cleaned. In many ways the piston is the life of the engine.

"Now, on engine liners little need be said. Some still cast the liner solid with the jacket walls, but gradually they are all coming to the removable liner. It gives little trouble and outside of reboring seldom needs attention."

"What about reboring?" Woods spoke up. "Can a liner be rebored?"

"Sure! It's often done. I believe any liner has ample thickness to stand one reboring. But in reboring the average engineer is up against a snag. Even where the plant contains several engines, it isn't profitable to own a boring bar, for that represents an investment of about six hundred dollars. Such a plant will not do enough reboring to cover the interest and depreciation. Our own company, with its several plants, has one, and of course it's used fairly often, especially on the old engines. A fair charge for reboring a cylinder from 16 to 18 in. in diameter is $150. So always recommend that this be performed by some shop that has a boring bar.

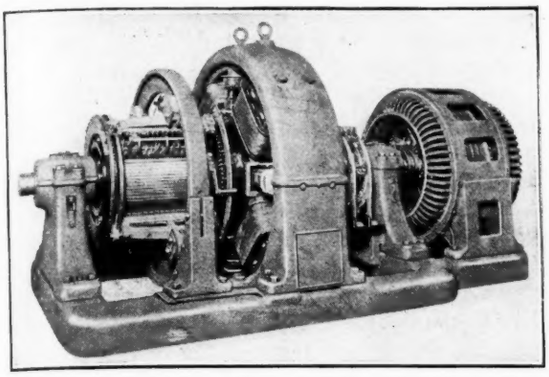
"There's one more thing, before we quit for tonight. You want to take care in pulling vertical pistons. As you know, there are usually two eye-bolt holes in the piston. I've noticed some of you are in the habit of merely passing a chain through the eyebolts and looping it over the hoist hook. Don't do that—you're liable to break off the bolts. Put a spreader between the parts of the chain, near the piston, so that the pull on each bolt is in line with its axis. Of course, if the piston is tapped for only one bolt, this doesn't apply."

Boiler Feed-Water Treatment and Metal Preservatives

BY P. R. DUFFEY

Many companies will purchase, upon a salesman's recommendations, a trial lot of water or metal treatment and with a few hasty instructions turn it over to the chief or operating engineer for trial. The engineer in turn, has probably learned to be doubtful of good results to be obtained, will make a hurried test perhaps in a haphazard way and condemn the possibly good and needed treatment.

In order that he may find out the truth the chief engineer, or the man held directly responsible for the boiler plant, should personally inform himself of all details possible for the manufacturer to give, and follow up the tests over a sufficient period of time to warrant his approval or rejection of the treatment. The manufacturer should conscientiously represent his goods and give the purchaser the benefit of his experience, impart all information possible and follow the method used by the man detailed to perform the test, being satisfied that a square deal is given each party. The water and metal treatments now on the market will no doubt do what is claimed for them if properly used, but if not used as intended, it is likely they will fail.



Electrical-Machinery Brush Composition

By WARREN C. KALB

The Various Types of Brushes Used on Electrical Machinery, Their Composition, Method of Manufacture and Field of Application

CONSIDERING brushes in relation to the materials of which they are composed, they fall into eight classes as follows: Carbon-graphite, graphite-carbon, graphite, electrographitic, metal-graphite, carbon-gauze, metal-gauze and copper leaf.

The carbon-graphite brush is the type usually spoken of as an ordinary carbon brush. It is composed principally of amorphous carbon, usually in the form of coke, to which is added sufficient graphite to give the brush some lubricating property and increase its conductivity to some extent. Natural graphite is generally used for this purpose, and as this usually contains a considerable percentage of foreign material of more or less abrasive nature, brushes of this class as a rule are abrasive to an appreciable degree.

The practice is quite common among both manufacturers and users to impregnate brushes of this class with some lubricating material. This not only tempers the abrasive characteristic of the brush and reduces its friction, but improves the commutating property as well, due to the higher contact resistance created by the film of lubricating material which forms at the brush face.

The disadvantages of this treatment are that it is driven off when the brush encounters conditions of high temperature. It has a tendency to collect dust from the atmosphere, and if this happens to be of an abrasive nature, as is the case around cement mills and similar service, the commutator wear resulting from this cause may be quite severe. Finally, brushes with lubricating treatment have a much greater tendency than others to collect copper on the face of the brushes.

Most brushes of the carbon-graphite class are within the medium range of hardness. They are not adapted to undercut mica, due to their abrasiveness and the artificial lubrication they generally require. Most grades of this class are of low carrying capacity and are not adapted to high peripheral speed. However, this type of brush will take care of a wide range of operating conditions within the limits of its characteristics and, considering its moderate price, must be classed as a good all-around brush.

There is another class of brushes in which a considerable or even the predominating percentage of the composition is graphite, the remainder being coke or some other form of amorphous carbon. These are known as graphite-carbon brushes. A great many grades of brushes fall within this class, so that the class as a whole covers a very large field of application, although the individual grades may not apply to such a broad range of service.

Brushes in this class usually contain sufficient graphite for lubrication, so that lubricating treatment is seldom used. Artificial as well as natural graphites are used, depending on the characteristics that it is desired to incorporate in the brush, and the abrasive properties will depend upon the graphite that is selected. Some brushes within this class possess very little abrasive action, while there are others possessing considerable. In point of hardness these brushes will range from soft to medium hard. The carrying capacity will usually be higher than the grades in the carbon-graphite class, but the contact drop of most of these brushes is medium or low unless a lubricating treatment is used.

Brushes of this type find an extensive application on industrial motors, moderate-speed generators, mining- and mill-service, and railway motors. Certain grades of this type are especially well adapted to fan motors, magnetos and other small machines both of the direct-current and universal types. Some excellent grades of moderate-priced brushes will be found among the various makes of graphite-carbon brushes.

There are numerous grades of brushes on the market composed entirely of graphite except for the binding material necessary to hold the particles of graphite together. These are characterized by high-carrying capacity, medium contact drop and low coefficient of friction, adapting them especially to high commutator speeds.

There are a few grades of graphite brushes on the market manufactured by special methods that give the material a very high resistance and a somewhat improved commutating characteristic over the ordinary type of graphite brush. These grades, however, have a rather limited field of application. There are also grades possessing very low specific gravity. These are manufactured in this way to reduce the inertia of the brush as much as possible, adapting it to very high rotative speeds.

Most brushes in the graphite class are nonabrasive or at most but slightly abrasive and should generally be used on commutators of which the mica is undercut. A few of the slightly abrasive grades can be used on unslotted commutators where conditions are not severe. All the brushes in this class are soft, some of them being very soft. They possess low mechanical strength, so are incapable of meeting severe mechanical conditions and should be operated at low spring pressure. Where quietness of operation is an essential characteristic, this type of brush has much in its favor. Classes of service in which they are used to a con-

siderable extent are as follows: Turbo-generators and other high-speed types, automobile-lighting generators, electric-vehicle and battery-locomotive motors, battery-charging and other low-voltage generators, slip rings and occasionally as lubricating brushes on electroplating generators.

Electrographitic Brushes

Perhaps the highest stage in the development of carbon-brush manufacture up to the present time has been reached in the electrographitic brush. This type is made up in the first place of certain forms of amorphous carbon carefully selected to give the desired characteristics to the finished product. In the final baking operation it is carried to an extremely high temperature, which results in a modification of the material composing the brush, leaving all or part of it in the form of graphite. It is possible to make this type as near absolutely nonabrasive as any brush can be made. It is also manufactured with varying degrees of abrasiveness to meet special requirements.

In relation to other types of brushes this class is hard and some grades are extremely so; still, owing to its dense structure high conductivity is attained. Mechanical strength and toughness are pronounced characteristics of nearly all grades. The commutating properties of brushes of this class are above the average, and by proper selection of raw materials it is possible to secure a very high contact drop without the use of any impregnating treatment. This high contact drop, combined with the high conductivity and low coefficient of friction, gives an ideal combination of brush characteristics, making certain grades applicable to a very wide field of service.

Electrographitic brushes have been used on practically every conceivable application except electroplating generators, and even on these the more graphitic grades are sometimes used for lubrication. The nonabrasive grades are especially well adapted for use on undercut commutators, the hardness of the brush giving a cleaning action, which polishes the surface of the commutator well without causing any wear. For use on collector rings the electrographitic brush is well adapted wherever mechanical conditions are severe, due to its greater ruggedness.

These brushes may be used up to current densities as high as 80 amperes per square inch on the alternating-current rings of rotary converters, and occasional instances of successful application at even higher current densities have been noted.

Trend in the Use of Brushes

The trend of development at the present time seems to be away from the use of metal-graphite brushes on slip rings and toward the use of graphite and electrographitic brushes at current densities that are suited to these grades. There are many things to be said in favor of this tendency on all classes of alternating-current machines. However, a serious objection is met with on induction motors of the slip-ring type where it is desired to keep the slip at as low a figure as possible. Here the higher contact drop of graphite and electrographitic brushes will result in a greater percentage of slip than will be experienced with metal-graphite brushes.

For certain classes of service a brush is required having a contact drop much lower than that possessed by any carbon brush, yet above that of pure metal. For this purpose brushes are manufactured of a composition made up of graphite and metal powder. Copper powder is used in some grades. However, pure copper powder does not make the best brush for use on slip rings, owing to its tendency to cut the rings. For this reason it is customary to alloy the copper to some extent with tin, zinc, lead or some other metal, making a brush that is much less liable to score the rings. Copper, however, remains the predominant element in the composition.

The materials are thoroughly mixed in the desired proportions with a binding material to hold the metal and graphite particles together. It is then molded at high pressure, after which it is baked to carbonize the binder. In some grades the binding material is omitted and the temperature carried to a point of partial fusion of the metal, so that the material is bound together into a compact mass without the use of any additional binding agent. In addition to raising the contact drop somewhat above that of the pure metal, thus making it possible to secure good commutation on machines of low voltage, the graphite has another function—that of lubrication. Where properly applied these brushes can be used on commutators and slip rings at a fairly high peripheral speed without difficulty being encountered.

Brushes for Use on Slip Rings

On machines of the commutating type the selection of the proper grade of brush depends largely on the commutating characteristics of the machine, a brush of sufficient contact drop being required to keep short-circuit current well within control. On collector-ring service the selection is based on the required carrying capacity of the brush and its freedom from cutting. The lower the contact drop the better suited for this service, other characteristics being correct.

Considerable difficulty has been encountered at times in the attempt to apply metal-graphite brushes to service on collector rings. This usually takes the form of rapid brush wear and serious cutting of the rings. Undoubtedly, this condition is influenced to a considerable extent by the relation between the composition of the ring and that of the metal in the brush.

Another source of considerable cutting has been the tendency to use too high current density in metal-graphite brushes. In best practice at the present time a current density of 125 amperes is never exceeded with brushes of the highest metal content, and it is a frequent practice to keep the current density down to 100 amperes or less.

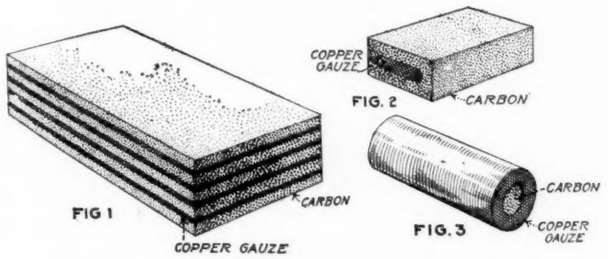
When current densities are kept this low on collector-ring service, much of the advantage of the composition brush is lost except on slip-ring type induction motors where it is desirable to keep the slip of the motor as low as possible. For this reason there is a growing tendency toward the use of graphite and electrographitic brushes on collector-ring service putting on brushes of sufficient size and in sufficient number to keep the current density around 75 to 80 amperes per square inch. This practice has an added advantage in certain classes of service, such as cement mills, where

the tendency for cutting is aggravated by the presence of an abrasive dust.

It is a characteristic of the composition brush that when the polish of the brush face and the collector ring is once destroyed there is a tendency for the cutting to continue for a considerable period before the polish again forms. This is not the case with electrographitic brushes and is one of the reasons this type of brush is meeting with increasing favor for service under conditions such as those just described.

While the tendency is away from the use of composition brushes on collector-ring service, this type of brush is still holding its own on low-voltage machines of the commutating type and possesses many advantages over any other type. Some of the classes of service in which it is extensively used are automobile-starting, lighting and ignition apparatus, railway-switch and signal motors, and electroplating generators.

One of the earlier attempts at the manufacture of composition brushes took the form of a carbon-gauze brush made up with alternate layers of metal gauze and carbon, Fig. 1, the carbon layers usually being



FIGS. 1 TO 3. TYPES OF CARBON-GAUZE BRUSHES

about ½ in. thick. This brush had an appreciably higher conductivity than the ordinary carbon brush, owing to the longitudinal layers of gauze. Its commutating property, however, approached that of carbon except for the narrow line where the gauze layer came in contact with the commutator. Owing to the tendency of the gauze to burn back from the contact face of the brush this brush was not successful on machines of high voltage. On low-voltage machines, however, it met with considerable success and is still used on some types of electroplating generators and low-voltage motors. It is especially well adapted to machines that must operate over a wide voltage range, such as certain types of switch motors which operate as a motor on 110 volts and generate a short-circuit braking current of low voltage after the power is thrown off the motor. An all-carbon brush of sufficiently high contact drop to commutate on 110 volts will not pick up the generating action quick enough to function properly on this type of motor. The presence of the gauze, however, accomplishes this result. This brush also finds considerable application on collector-ring service.

Small brushes of carbon and gauze combination are frequently manufactured by inserting a core of metal gauze in a hollow shell of carbon, Fig. 2. Still another type is made by winding a few layers of gauze around a core of carbon or graphite, Fig. 3. Such brushes have a limited field of application on magnetos and certain machines of special design.

In the last two types of brush it is customary to use brass gauze instead of copper, inasmuch as sufficient conductivity is given to the brush in that way and the brass gauze is much less liable to scratch a commutator than is copper gauze. In the layer type of brush, however, where the area of contact of the gauze is distributed, this precaution is not necessary and copper gauze is used. There is no fixed ratio for the proportion of gauze to carbon in these brushes, the types illustrated representing what is perhaps an average proportion.

Metal-gauze brushes are composed entirely of metal gauze, the process of manufacture being to wind this gauze into a roll as compactly as possible, after which it is pressed into the desired shape. In some cases the pores of the brush are then impregnated with graphite to furnish a lubricating action. This type of brush finds some use on automobile-starting motors, electroplating generators, and slip-ring service, but is being largely superseded in all of these fields by the metal-graphite composition brush.

Copper-leaf brushes are composed of a large number of layers of thin copper strapped or soldered together at different points to prevent their spreading. About the only application to which this type of brush is adapted is collector-ring service. Even on this service it is troublesome, requiring frequent attention to keep the face of the brush trimmed up and the rings lubricated to avoid cutting, therefore it is rapidly passing out of use.

(The next and last article will consider the application of brushes to electrical machinery to meet the conditions met with in various industries.)

A Legal Aspect of Boiler Rooms

BY A. L. H. STREET

An employee of a factory in an occupation unrelated to the power plant, on coming to the factory one morning pursued common practice in going to the boiler room and placing on a boiler a bottle of tea to keep it hot until her midday meal. On her way out of the boiler room she slipped on a staircase and was injured. Her right to collect compensation under the New York Workmen's Compensation Act was denied on the ground that she was not injured within the course of her employment, within the provisions of the act. But the Appellate Division of the New York Supreme Court overrules this contention and sustains an award in claimant's favor, saying:

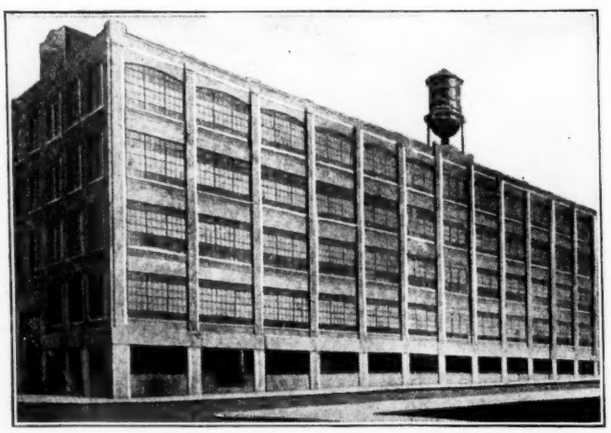
> In order to be acting in the course of her employment, it was not necessary that she should have been actually engaged in the work thereof. It was sufficient if she was performing some act upon the premises of her employer which, though directly beneficial to herself, was an ordinary incident of a day of employment.
>
> This claimant was performing such an act in placing her bottle of tea upon the boiler to keep it hot for a midday meal. Of course, if she had been forbidden to enter the boiler room, she was acting in violation of her duty and therefore not in the course of her employment. It is true that her employer had long previously promulgated a rule prohibiting the use of the boiler room and the boiler by its employees. However, it was the common practice of employees at the time of the accident to make use of the room as did the claimant. The acquiescence of the employer in this practice was sufficient to abrogate the rule. (Etherton vs. Johnstown Knitting Mills Co., 172 New York Supplement, 724.)

The Mechanical Equipment of Industrial Buildings—I

By CHARLES L. HUBBARD

The author treats broadly of the selection of equipment for industrial buildings. In this installment he considers sources of power and power and heating requirements.

THE accompanying illustration shows a type of building that has been erected in large numbers during recent months, owing to war conditions. Something relating to its mechanical equipment should therefore be of especial interest to designing and operating engineers. The subject will be treated somewhat broadly, taking up matters connected with the selection and arrangement of equipment and general methods of operation rather than details of construction. The great variety of manufactures carried on in such buildings makes it impossible to touch upon the special devices employed in actual production, but such matters as power generation and distribution, heating, ventilating, etc., are more or less common to all, and this article will therefore be confined to those subjects.



COMMON TYPE OF MODERN INDUSTRIAL BUILDING

There are three possible sources of power, depending upon local conditions: Electric power, purchased from a central station; a private water-power development, either adjacent to the building or having electrical energy transmitted from a distance; and a steam plant located on the premises. If power can be purchased at a sufficiently low rate, it has certain advantages that should be carefully considered. Among these may be mentioned the element of time, conservation of fuel, saving in space and general convenience. In many cases buildings of this kind are rushed to completion so that if the construction of a power plant may be eliminated the saving in time will often prove an important factor.

Furthermore, the possibility that the business may be of a temporary nature (for the duration of a war, for example) should be taken into account, and this may lead to the immediate purchase of power with the idea of adding private power equipment should the plant later become established on a permanent basis. Conservation of fuel, even if the cost to the owner of the plant is practically the same, should be taken into account for both patriotic and private reasons. In general, less fuel will be required per unit of power developed in a large central station than in an isolated plant, and if the central station develops its electricity by water power the saving in fuel will of course be still greater. Under present fuel conditions it may work out to the advantage of the plant owner to purchase power, even though it may cost more than to generate it on the premises, as the supply may be more reliable. For example, if power is obtained from a large hydroelectric plant, fuel shortage will have no direct effect on the continuous operation of the factory, and even when purchased from a station employing steam power there is less liability of interruption than would be the case with a private plant of much less importance. An enforced shutdown of a week or two, due to fuel shortage, would offset a considerable difference between the cost of power from a private plant and that from a central station.

Saving in space is often a deciding factor in purchasing power, especially when the building is located where land is expensive. In taking into account the space occupied by a power plant, it is necessary to include not only that required for the generating units and their auxiliaries, but also that necessary for the storage of coal, the handling of ashes and possibly side tracks, etc., connected with this equipment. As a matter of general convenience, nearly all points are in favor of purchased current. There is less likelihood of a shutdown for repairs, and many details relating to water and fuel supply are eliminated. It is true that the buildings must be heated, but this is necessary for only about half the year, whereas power requirements are continuous. Until the advent of electrical transmission of power it was necessary, in case of water-power development, to locate the factory beside the stream. As other requirements had to be considered, such as transportation, nearness to centers of population, etc., steam power was largely relied on for driving shops and factories, except in special cases.

Electrical transmission, together with the shortage of fuel, has again turned the attention of the engineer to the development of unused water powers. While the more extensive ones have already been taken up by large power companies, there are still available good opportunities on some of the smaller streams for the development of power sufficient to supply the needs of factories of fair size. When these are within reasonable distance of desirable sites for manufacturing plants, they should be considered as possible sources of power. When the time element is an important factor, or where there is a liability that the life of the factory may be limited to the special market conditions caused

by a war, it may not be advisable to consider hydraulic power unless the outlook is especially favorable. In instances of this kind it may be possible to purchase power temporarily, with a view to installing a private hydro-electric plant at a later date if market conditions favor a permanent layout of this kind.

In each of the cases thus far considered, attention has been confined to the power side of the problem only. In the greater part of the country, and especially in the more important manufacturing sections, the factory must be heated for a period ranging from four to seven months of the year. This condition has an important bearing on the selection of a source of power because during the heating season, when exhaust steam can be utilized for heating and ventilating, the actual fuel requirements for power alone are comparatively small. For example, in the average case, less than 20 per cent. of the steam supplied to the engine is condensed in the performance of useful work and in the cylinder losses.

If an engine is using 24 lb. of steam per indicated horsepower-hour and 80 per cent. of this is utilized in heating the building, only $24 \times 0.20 = 4.8$ lb. of steam per indicated horsepower can be charged to power development. The building must be heated, and if the steam can first be passed through an engine or turbine the actual expenditure for power will be very small, as just shown. In making an estimate of this kind, however, it is necessary to consider only the exhaust that can be utilized and not that which is produced; and furthermore, the entire twelve months of the year must be taken into account. In a general way, the heat loss from a building of this type is large, and perhaps all, or at least a considerable portion, of the exhaust can be utilized, especially in the colder months. In other cases, where the manufacturing is of such a nature as to require only a minimum of power, the exhaust may not be sufficient for heating purposes, in which case the full benefit will be realized, as in the example previously given.

Steam Charged to Power Account

Suppose, for illustration, that the available exhaust is just sufficient for all heating purposes in zero weather and that the plant is run 2700 hours per year. Suppose also that the heating season lasts seven months, with an average outside temperature of 35 deg. F. (average conditions for New England and similar latitudes). Taking the same engine as before, the steam requirements per horsepower per year are $24 \times 2700 = 64{,}800$ lb. While the total exhaust, or $24 \times 0.80 = 19.2$ lb. per indicated horsepower-hour, can be utilized for heating in zero weather, only half that, or $19.2 \div 2 = 9.6$ lb., can be utilized per hour when the average heating season is considered. Assuming a heating season of 1638 working hours (seven months with twenty-six 9-hour working days per month), it will be possible to utilize $9.6 \times 1638 = 15{,}725$ lb. of steam per indicated horsepower, bringing the total to be charged to power down to $64{,}800 - 15{,}725 = 49{,}075$ lb. per i.hp., or $49{,}075 \div 2700 = 18.2$ lb. per i.hp.-hr., when the average for the entire year is considered. From these results, the steam to be charged to the power account, under different conditions, is as follows: In zero weather, 4.8 lb. per i.hp.-hr.; average for the heating season, 18.2 lb. per i.hp.-hr.; and during the nonheating season, 24 lb. per i.hp.-hr.

With these data at hand it is possible to make a comparison of costs between purchased power and that generated on the premises, taking into account, of course, fixed charges on the cost of the private plant. This evidently applies only to the particular conditions assumed and for simplicity takes into consideration only the average day load for operating the plant. Additional power required for lighting, where the exhaust must be thrown outboard, must be charged up to the annual power account, thus increasing the steam per horsepower-hour. If, on the other hand, the normal day load failed to furnish the required amount of steam for heating, then the additional lighting load during the evening would furnish more available exhaust and thus reduce the annual fuel cost per horsepower-hour based on the normal day load, as in the example.

Advantage of Private Steam Plant

The principal advantage of the private steam plant comes from the low cost of power when conditions are such that the exhaust can be utilized to advantage for heating purposes, and this should always be taken into account when comparing this source of power with hydraulic power or central-station service.

Among the governing factors in the selection of a boiler are the pressure to be carried, size and number of units, available space and cost. To these may be added such details of construction as relate especially to accessibility for inspection, cleaning and repairs.

When boilers are furnished by builders of established reputation, it is not usually necessary for the engineer to prepare detailed specifications. General requirements as to pressure, amount of heating and grate surface, type of furnace and setting are furnished the builder and from these he in turn prepares specifications for the owner or his engineer, which are submitted with his bid. This applies especially to water-tube and patented boilers, of which there is a great variety. In the case of horizontal fire-tube boilers the engineer often furnishes specifications, particularly when any departure from standard construction is desired.

Choosing Type of Steam Boiler

In making a choice between fire-tube and water-tube boilers, one must be guided largely by local conditions. So far as efficiency is concerned, for a given size, there is very little difference provided they are designed and operated with equal care. In general, return-tubular boilers are more frequently confined to plants of small and medium size and to pressures not exceeding 150 lb. per sq.in. Individual boilers are commonly limited to about 150 rated horsepower, which corresponds to a 72-in. shell with ninety-eight 3½-in. tubes 19 ft. in length. While larger sizes might easily be constructed, it has been found by experience that the shell plates should not exceed ½ in. in thickness, or ⅝ in. at the most, which limits the diameter possible with a given pressure. Boilers of this type are lower in first cost than water-tube boilers, they require a minimum of repairs, and when properly designed and set, all parts are comparatively easy of access for inspection and cleaning.

For larger units and higher pressures the water-tube boiler has largely superseded the horizontal fire-tube type. It is more expensive to install for a given capacity, but requires considerably less floor space. It is made

in units of all sizes ranging from about 50 hp. up to 2000 hp. or more, so that almost any division for a given capacity may be obtained. Water-tube boilers respond quickly to changes in load and are practically immune from dangerous explosions.

In laying out the boiler plant for a manufacturing establishment, the first step is to determine the maximum steam requirements for all purposes, in pounds per hour from and at 212 deg. F., which, divided by 34.5, will give the nominal horsepower rating. The greatest steam consumption will depend on the relation between the power and heating requirements. In determining this, compute the maximum steam requirements for power and heating separately, also the average day load when lights are not required. If the available exhaust steam from the day load exceeds the maximum heating requirements, then the boiler capacity may be based on the power load alone. If, however, the maximum heating requirements exceed the available exhaust from the average day load, then the boiler capacity must be based on the power requirements at day load plus the steam necessary for heating in addition to the exhaust at day load. Furthermore, this should be checked up with the available exhaust from the maximum evening load, and if the latter is not found sufficient for all heating purposes, the total boiler capacity must be based on the evening power load plus the additional steam for heating instead of on the day load. The "power load" should include all engines, turbines, pumps, etc., of whatever kind, which are supplied with live steam, while the term "heating requirements" should include warming the buildings, ventilation, hot-water service, feed-water heating, etc.

Economical Overloads for Boilers

Having determined the maximum boiler capacity in pounds of steam per hour, or its equivalent rating on a basis of 34.5 lb. per horsepower-hour, the next step is to decide on the amount of heating surface, or, to put it a different way, the percentage of overload that can be economically carried above the normal rating. Fire-tube boilers are commonly rated at one nominal horsepower for each 12 sq.ft. of heating surface and water-tube boilers on a basis of 10 sq.ft. of heating surface. With improvements in furnace construction and methods of operation, so as to burn larger quantities of fuel per unit of heating surface under conditions more nearly approaching complete combustion, it has been found that the capacity of a given boiler may be greatly increased with only a slight drop in efficiency, while in some cases the efficiency is actually increased up to a certain point.

While many tests have been run which show that a boiler may be made to develop a capacity of from 250 to 300 per cent. of its normal rating at a relatively high efficiency, the most desirable overload in any given case will depend on various circumstances, such as length of run, whether continuous or intermittent; method of firing, whether by hand or with stokers; design of furnace and method of supplying air, etc. While the best rate of forcing can be determined only by test, the following may be taken as a guide in laying out new work equipped with boilers and furnaces of the best design of medium size: For continuous operation, 24 hours per day, 125 to 150 per cent. above rating; for 10- to 12-hour runs, 150 to 175 per cent.; and for peak loads of 2 or 3 hours' duration, 175 to 200 per cent. These figures apply especially to plants equipped with mechanical stokers, where the rate of fuel supply is easily increased. In case of hand-fired plants the increase cannot usually be carried above 150 per cent. under average conditions.

The importance of increasing the capacity of a boiler in this way is readily seen, especially in shops and factories where a lighting load must be added to the ordinary day load for a varying length of time depending on the season of the year. If this can be done without adding to the number or power of the boilers required for the day load, simply by forcing them from 150 to 200 per cent., it will save materially on the first cost of the installation as well as on the expense of carrying banked fires for 20 hours or more when the boilers are to be used only 3 or 4 hours per day at the most.

Value of Mechanical Stokers

While the capacity of a boiler must necessarily be determined by the weight of steam to be furnished in a given time, its normal rating on the usual basis of 10 or 12 sq.ft. of heating surface per horsepower will depend on the percentage of overload it is deemed advisable to carry at times of maximum demand in any given case. It has already been stated that increase in boiler capacity depends principally on the ability to supply and burn more fuel. The first requirement is limited in the case of hand-firing; hence the importance of mechanical stokers in this connection.

The value of mechanical stokers will depend largely on the size of the plant, the percentage of overload it is desired to carry, and the possibility of installing overhead chutes and coal-handling machinery. They are generally employed in plants of 1500 hp. and over, and have also been found effective in many cases where the boiler capacity did not exceed 200 or 300 hp. As the plant diminishes in size, their advantage is offset by the added cost, not only of the stoker itself, but of the other equipment that goes with it, such as coal- and ash-handling machinery.

Factors Governing Use of Stokers

Among the factors that govern the use of mechanical stokers are the grade of fuel to be used, cost of skilled labor, and smoke regulations. Under ordinary conditions one efficient fireman can attend to about 200 hp. of hand-fired boilers, while with mechanical stokers with overhead coal bins and chutes, he can easily care for a plant of 1000 to 2000 hp., depending on the grade of fuel and type of equipment. The chief advantages of this method over hand firing are saving in labor, a uniform supply of coal without opening the feed doors, and greater accuracy in proportioning the air supply to the needs of combustion, all of which are in the line of greater efficiency.

When fuel economy is an essential feature, as at the present time, a considerable saving may be made by the use of superheated steam. It has not been used in this country to any great extent in the past in connection with reciprocating engines, owing to the difficulty experienced in lubricating the cylinders and to the unequal expansion produced at such high temperatures. Improvements in design and in lubricating oils have

overcome these obstacles to such an extent that superheat is now quite generally employed in the best class of work, especially in the case of turbines.

In American practice the degree commonly employed runs from about 100 deg. to a maximum of 160 deg., being limited to a total temperature of about 500 deg. F. for engines of ordinary construction. Beyond this point the expense of maintaining the superheat and increased cost of construction and maintenance soon offset the gain in economy. The saving in steam consumption depends principally on the reduction in cylinder condensation and varies with the operating conditions.

Tests of a simple noncondensing engine of medium size show a saving of 20 per cent. with 150 deg. of superheat, and 25 per cent. with 225 deg., which correspond with a saving of 1 per cent. for each 7.5 deg. rise at the lower temperature and for each 9 deg. at the higher. A compound condensing engine of the same power shows savings of 15 and 20 per cent. for the same relative conditions, corresponding to a gain in economy of 1 per cent. for each 10-deg. rise at the lower temperature and for each 11.2 deg. at the higher. Comparison of these results shows a falling off in effectiveness as the temperature increases, and a greater gain in the case of the simple engine than the compound, both of which are borne out in practice. These figures simply show the reduction in steam consumption without regard to the cost of superheating. The net gain in economy is usually not far from half of the apparent gain when the water rate only is considered.

Superheaters of the indirectly fired type, contained in the regular boiler setting, are usually employed in this class of work, owing to their lower first cost and greater compactness.

The Electrical Study Course—Two-Wire Versus Three-Wire System

Shows in what respects the three-wire system overcomes the disadvantages attendant upon operating lamps in series on a two-wire system, and gives the manner of determining the relative amounts of copper required in the mains of three-wire systems as compared with those required in two-wire systems. Also proves that in a three-wire system the percentage of energy lost in the line and the percentage voltage drop therein vary with the amount of unbalancing.

IT WAS stated in a previous lesson that the three-wire system overcomes the disadvantages encountered in operating 110-volt lamps in series on a 220-volt service and yet retains in a large measure the advantage that a 220-volt two-wire system was shown to possess over a 110-volt two-wire system; namely, that of using one quarter of the copper in the mains to convey the same amount of power with the same loss.

The chief disadvantage of the series plan is that both lights of a set must always be used together. They are either both burning or both out. The three-wire system overcomes this undesirable feature, since turning off one or any number of lamps between one outside and the neutral wire has no effect whatever on the rest of the lamps; all that it does is to cause current to flow through the neutral wire. The accidental burning-out of a lamp on one side will likewise not disturb the others.

If a short-circuit should occur in a lamp, there will be no excess voltage across any other lamp as is the case with the series connection, and consequently only the one lamp will be affected and there will be no disturbance except the possible blowing of a fuse. Thus it is seen that the principal drawbacks of the straight series arrangement are obviated by the three-wire system.

In proceeding to the matter of the saving of copper in the three-wire system, it will be remembered that in two-wire systems the weight of copper required varies inversely as the square of the voltage employed when equal loads are to be transmitted like distances with the same loss in the line. That is, if the voltage is doubled the weight of wire required would be quartered. To bring out the relations clearly and to show what the conditions in the three-wire system are, reference will be made to Figs. 1, 2 and 3, which represent a two-wire 120-volt, a two-wire 240-volt, and a three-wire 120- to 240-volt system respectively; all are supposed to be of the same length.

Assume that the load in every case is twelve 200-watt 120-volt lamps arranged as shown, and that the line loss is the same in all three cases. The total load on each system would be $12 \times 200 = 2400$ watts. The current in the 120-volt system would therefore be $\frac{2400}{120} = 20$ amperes, and that in the 240-volt system $\frac{2400}{240} = 10$ amperes. Since the loss in a line is equal to I^2R, and this loss is to be the same in all the systems, we have $(10)^2 \times R_2 = (20)^2 \times R_1$, where R_2 and R_1 are the resistances of the 240-volt and 120-volt lines respectively. From this we see that $100R_2 = 400\ R_1$, or $R_2 = 4R_1$. That is, the resistance of the 240-volt line is four times that of the 120-volt one, and in order for this to be so the wire in the former must be one-quarter the cross-section of the latter and consequently one-quarter of its weight for the same length.

Coming now to the three-wire system of Fig. 3, the current in each of the outside wires is that taken by six of the lamps—that is, 10 amperes—and the current in the neutral is their difference, namely, zero. We therefore find that this case is identical with the straight two-wire 240-volt system, since the neutral wire could be eliminated and it would operate exactly as does the two-wire arrangement. Consequently, the size, and therefore the weight, of the outside wires would be the same as those of the wires of the two-wire system. To this, however, must be added the weight of the neutral in order to get the weight of copper for the entire system.

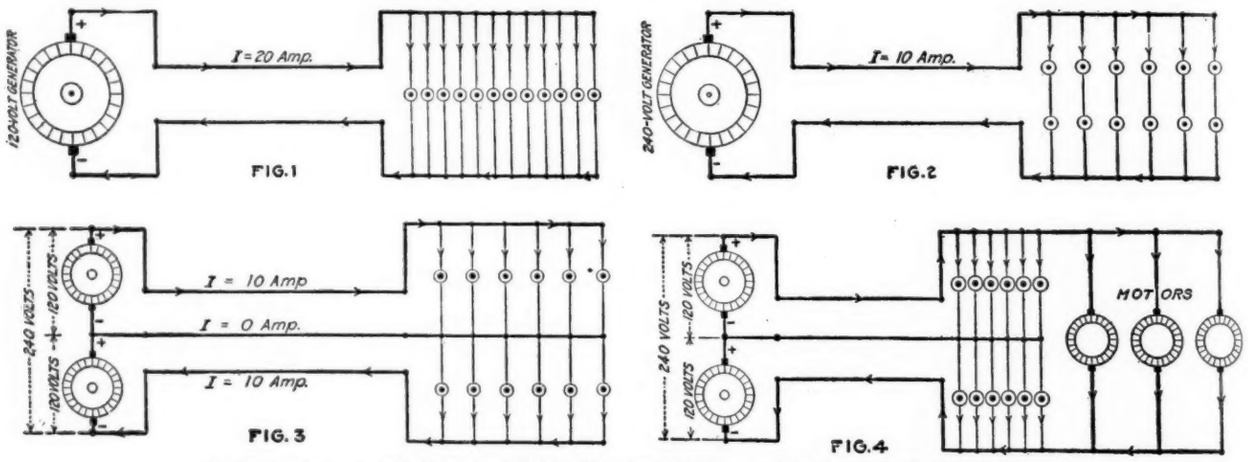
It was found in the preceding lesson that the maximum current in the neutral would flow when all the lamps on one side were lighted and all those on the other extinguished. Hence the maximum current in the neutral will be the same as the maximum in either outside wire, in this case 10 amperes. Since it must be prepared to carry the same current as the outside wires, it must also be of the same size. This means that the weight of the additional wire must be the same as the other two.

From the foregoing deductions we have the following relations: The weight of the copper in the 240-volt system is $\frac{1}{4}$ that of the 120-volt one, and the weight in the three-wire system is $1\frac{1}{2}$ times that of the 240-volt one. To make the comparison as simple as possible, assume that the weight of the copper in the 120-volt system is represented by W. Then that in the 240-volt system will be $\frac{1}{4}W$, and that in the three-wire system $1\frac{1}{2}(\frac{1}{4}W) = \frac{3}{8}W$. That is, the copper in the three-wire system weighs $\frac{3}{8}$ as much as that in an equivalent two-wire 120-volt system, compared with $\frac{1}{4}$ as much for a two-wire 240-volt system. It is therefore evident that the three-wire system affords a very material saving in copper, even if it does require somewhat more than does the two-wire 240-volt system.

While it is usual practice to make the neutral wire of the same size as the outside ones, there are cases in which it may be made smaller. If a considerable load is to be supplied with current at the higher voltage, as, for example, the motors in Fig. 4, then the size of the outside wires must be such as to safely carry the sum of the lamp and motor currents, but the neutral wire need be only of the size required to carry the lamp current, since it can never be called upon to carry more than that required by the lamps on one side of the circuit.

It might appear that when the load on a three-wire system consists of lamps used under conditions which make it certain that the load will never be unbalanced very greatly, the neutral wire may be made smaller than the outside ones, since the current through it would always be comparatively small. It must be remembered, however, that the fuse in one of the outside lines might blow, and then the neutral would have to carry as much current as the outside wire. Furthermore, the National Board of Fire Underwriters' code requires that the neutral for the three-wire load must be the same size as the outside conductors.

The percentage loss in a three-wire system is the least when the load is balanced. It is therefore necessary to distribute the lamps in such a manner that the load shall be as nearly evenly divided between the two sides at all times as possible. To show how the percentage of loss increases when the load is unbalanced, let us investigate what happens in the system of Fig. 3 when all the lamps on one side are turned off. The load remaining will then be half of what it was—namely, 1200 watts—and the current in the active outside wire and in the neutral will be 10 amperes. Suppose the resistance of each of the mains is 0.2 ohm. Then the loss in each wire will be $I^2R = (10)^2 \times 0.2 = 20$ watts, and in the two twice that, or 40 watts. The ratio of the loss to the load will therefore be $\frac{40}{1200}$, which multiplied by 100 will give the per cent. loss; that is, $\frac{40}{1200} \times 100 = 3\frac{1}{3}$ per cent. On the other hand, if the system was fully loaded we would have 10 amperes in each outside wire and no current in the neutral. The loss would therefore be the same, but the load supplied is now twice as great as before, 2400 watts, and the per cent. loss is therefore $\frac{40}{2400} \times 100 = 1\frac{2}{3}$ per cent.; that is, one-half of what it was before. For degrees of unbalancing between these two limits the per cent. loss will lie somewhere between the values found.



FIGS. 1 TO 4. DIAGRAMS OF TWO-WIRE AND THREE-WIRE SYSTEMS AND LOADS

In like manner the per cent. voltage drop in the line is affected by the amount of unbalancing. Thus, when the load is balanced there is a drop in each outside wire of $IR = 10 \times 0.2 = 2$ volts, or a total drop of $2 \times 2 = 4$ volts. Since the voltage across the outside wires is 240 volts, the per cent. drop is $\frac{4}{240} \times 100 = 1\frac{2}{3}$ per cent. When all the lamps on one side are turned out, thereby causing 10 amperes to flow in one outside wire and in the neutral, we again have a drop of $IR = 10 \times 0.2 = 2$ volts in each of two wires, or $2 \times 2 = 4$ volts altogether. In this case, however, the lamps that are burning are being supplied with current at 120 volts, and hence the per cent. drop in voltage is $\frac{4}{120} \times 100 = 3\frac{1}{3}$ per cent.; twice what it is in the case of balance load.

The problem given in the preceding lesson was to find the currents in the three lines of a 110- to 220-volt three-wire system supplying power to lamps and motors as represented in Fig. 5. The load H consists of eighty 50-watt and thirty 100-watt lamps, K consists of seventy

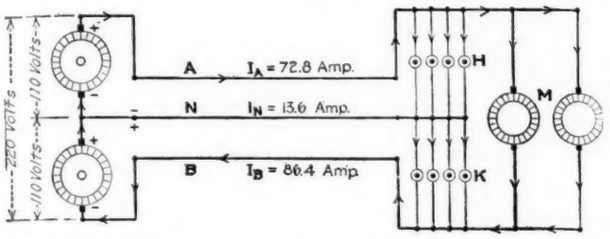


FIG. 5. THREE-WIRE LOAD CONSISTING OF LAMPS AND MOTORS

50-watt and fifty 100-watt lamps, and M consists of one ½-hp. and one 2-hp. motor, both of which are operating at 75 per cent. of full load. The load H would use $(80 \times 50) + (30 \times 100) = 7000$ watts, and load K $(70 \times 50) + (50 \times 100) = 8500$ watts. These two loads are supplied at 110 volts, consequently the currents required by them would be $\frac{7000}{110} = 63.7$ amperes and $\frac{8500}{110} = 77.3$ amperes respectively. For the motor load we multiply the horsepower output by 746 to convert it into watts. The output of each machine is stated to be 75 per cent. of its full rating. We therefore have that the total output is $(0.75 \times \frac{1}{2}) + (0.75 \times 2) = 1.875$ hp., and multiplying this by 746 we have $1.875 \times 746 = 1399$ watts. The average of the efficiencies of these motors was assumed to be 70 per cent., hence we have $0.70 \times$ input $=$ output, or input $= \frac{\text{output}}{0.70} = \frac{1399}{0.70} = 1999$ watts. Since this load is supplied at 220 volts, the current required by it will be $\frac{1999}{220} = 9.1$ amperes. The current in the outside wire A will be the sum of the currents of H and M—that is, $63.7 + 9.1 = 72.8$ amperes—and the current in the outside wire B will similarly be the sum of the currents used by K and M, or, $77.3 + 9.1 = 86.4$ amperes. The current in the neutral N will be the difference between the currents in A and B, which is $86.4 - 72.8 = 13.6$ amperes.

A total load of 46 kw. is to be supplied with current at 115 volts by a three-wire system. What size wire must be used for the line if the system is balanced?

Changes in Equipment Effect Savings in a Municipal Plant

By J. T. SHARP, Jr.

A municipal water and light plant makes large savings in coal by replacing old equipment and using a compound instead of a simple engine.

THE City of Canton, Mississippi, has owned and operated its water and light plant with varying degrees of success for the last 23 years. The first electrical generating outfit was a 37½-kw. alternator and a series arc machine of 40 lights capacity, belted to a Buckeye high-speed engine. There were two 100-hp. return-tubular boilers and the water-works was supplied with two 750-gal. duplex pumps. In a few years, due to flat rates, the small alternator was loaded to the place where no more lights could be taken on, and at this time there was purchased a 100-kw. alternator and an 18 x 42-in. Corliss engine and a 150-hp. water-tube boiler.

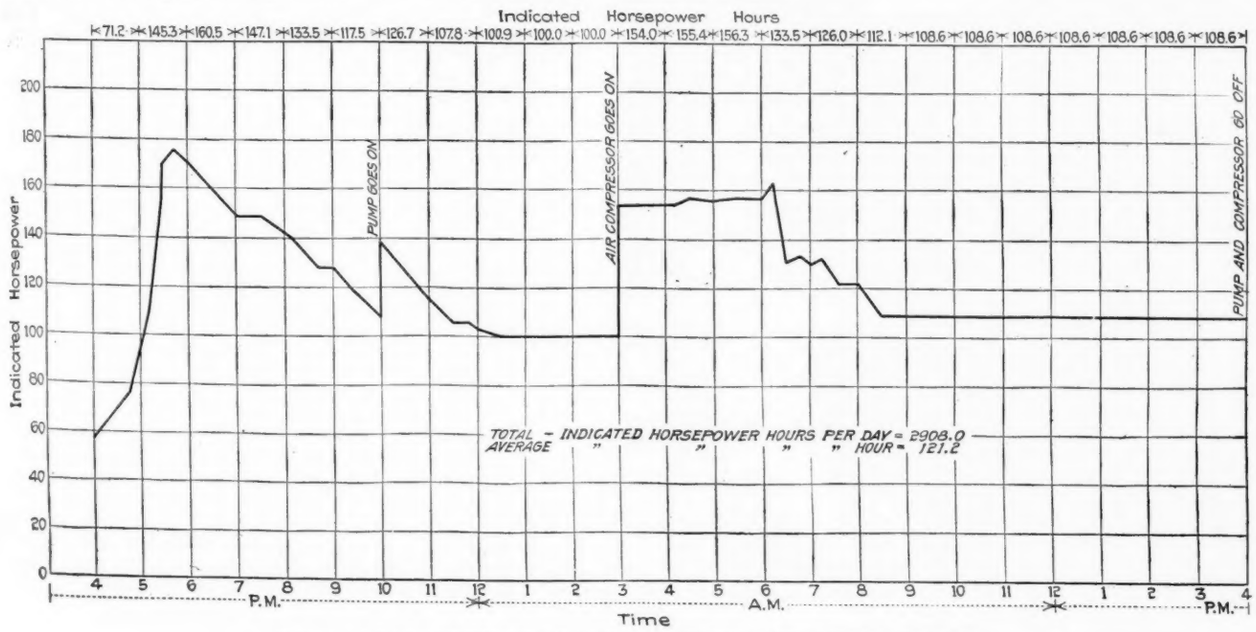


FIG. 1. LOAD CURVE OF MUNICIPAL WATER AND LIGHT PLANT

The Corliss engine as well as the Buckeye was belted to a lineshaft in the new engine room, which was provided to take care of the new equipment. The series arc machine was also used for a while until it was displaced with a modern series arc lighting system using alternating current. This lineshaft was used a number of years and was disposed of, and the Corliss was belted to a second-hand 150-kw. alternator and the Buckeye was belted to the 100-kw. machine already on hand. A small Ideal engine was bought and belted to the 37½-kw. alternator. It was about this time—early in 1906—that the service got so undependable and the expense of running the plant so great that it was decided to change the plan of management and put the plant in other hands, and it was then that the writer was put in responsible charge of the plant.

In a little while it became necessary on account of the additional amount of water used by the sewer system to use compressed air to pump the wells, and a compound two-stage air compressor was purchased, together with a 14 and 20 x 15½ x 15-in. water pump. The smaller Ideal engine was traded off and a larger engine bought and belted to a 52-kw. alternator in place of the 37½. The boiler plant at this time consisted of a 72-in. x 20-ft. 200-hp. boiler with steel setting and a 150-hp. water-tube boiler. It was deemed best on account of the age of the latter boiler and the inefficiency of the former to add another 200-hp. water-tube unit.

In December, 1913, due to the constantly increasing cost of fuel, we addressed a number of letters to various engine builders asking for quotations and guarantees on a direct-connected type of engine to be provided

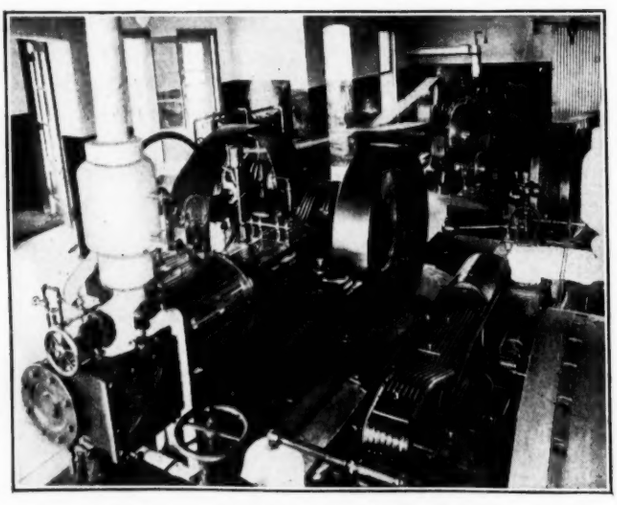


FIG. 2. VIEW OF PLANT EQUIPMENT

with belt wheels, mounted in the space usually occupied by the rotor of the direct-connected generator, and from which could be belted an alternator, an air compressor and a centrifugal pump. A log was taken of the electrical load, and the amount of compressed air needed was determined as well as the amount of water to be pumped. The correspondence covered a long period of time, and finally it narrowed down to the fact that all the manufacturers were very anxious to sell machinery, but only a single one would sell the outfit and file a bond as to the performance of the whole outfit. This company guaranteed to furnish us an 11 and 18 x 15-in. tandem compound engine, a 354-cu.ft. belted air compressor, a 500-gal. two-stage centrifugal pump, and also a 5 x 3 x 7-in. boiler-feed pump. The engine was to be belted to the compressor and pump as well as the 100-kw. alternator we already had on hand.

The contract provided that the alternator was to be run 24 hours per day on the electrical load as given and that the compressor was to be used for 14 hours per day and that the pump was to be operated for 18 hours per day. In performing the work as indicated by the load curve shown in Fig. 1 there was to be used not over 6.1 tons of mine-run coal based on the evaporation of

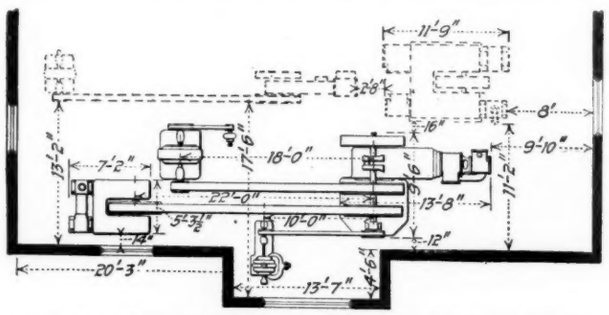


FIG. 3. ARRANGEMENT OF MACHINERY IN CANTON PLANT

the boiler as obtained previously with a test, which guarantee was backed up by a bond for the full delivered price of the engine.

A general view of the machinery is given in Fig. 2, and the arrangement of the machinery on the engine-room floor and the distances of the belt centers are shown in Fig. 3. The installation was put in and in November, 1915, was operating, although it was not put regularly into operation until Dec. 1, 1915. The new outfit came entirely up to the guarantee, and in addition to operating it, we operated the compound pump for four or five hours per day and at times it was necessary to operate the steam-driven air compressor. In spite of all of this the combined outfit still was inside the limit of coal supposed to be used on the new outfit alone. A test disclosed the fact that the new outfit was about 18 per cent. ahead of the guarantee on daily coal weights.

Our coal bill for 1915 was $8746.33 and for 1916 was $6150.48, giving a difference of $2595.85, to which will have to be added $345.14, making a total of $2940.99, or a percentage difference of 33.6 per cent. The addition of $345.14 was caused by having a raise of 10c. per ton on freight rate and the coal contractor not being able to supply us with sufficient coal, so that we were forced to buy in the open market.

For more than five years the plant has had industrial track scales and every pound of coal that is used for the plant is weighed. At the present time the new outfit is operating on a 24-hour schedule with a stop of one to two hours on Saturdays to be cleaned up and to have the bearings adjusted. During 1916 the total lost time from all causes was 1.8 per cent., and during 1917 it was 1.76 per cent. Of course this would not be a good record for a turbine, but it is certainly a good record for a reciprocating engine. The percentage of lost time covers stops on account of trouble with the air compressor, centrifugal pump, generator and engine.

At first this plant was started 133-cycle and all sub-

sequent machines were bought 133-cycle. For the use that this town has for light and power, they fill the bill as well as 60-cycle apparatus, but as soon as the old machines are worn out it is the intention of the management to change to 60 cycles. During the last year not a minute was lost from service of night lighting by power-house troubles. All the necessary material is carried in stock to wind the armature coils when they burn out, which they do sometimes. A machine shop located in the same building next to the engine room is a part of the equipment and is very convenient when repairs have to be made.

An Adventure with "Static"

By B. J. Randall

In a large central station where I was employed as an engineer there was a fellow engineer, an inveterate practical joker, who was continually on the lookout for any jokes that we might endeavor to subject him to, and he did not always take it with good grace when we succeeded in putting something over on him.

One Sunday morning we received orders to cut the steam off from a section of the main steam line. This pipe was 14 in. in diameter, and we cut out about a hundred feet of it to repair some valves. With a pressure of 160 lb. there was considerable steam contained in this section, and the only way to bleed it was by a small valve which was reached by a ladder placed on the engine-room floor. Charley McGregor, as we will call him, was in charge of the watch at the time, and superintended the cutting-out process. When all the necessary valves were shut, he got up on the ladder to bleed the line of all pressure. This line was vertical, running through three galleries to the top fire-room, and the repair gang had taken their places directly above McGregor, waiting for him to complete his part of the work. He opened the bleeder gradually, until the steam was roaring from the line, and then descended the ladder to speak to the first assistant, who was looking on.

"Have you got the bleeder open full, Charley?" the latter asked.

"No, but I will have it open soon," was the response, and the speaker mounted the ladder to open the valve some more.

The next moment, a mixture of yells and imprecations was flooding the atmosphere. If there was one thing that McGregor could do to perfection, it was shout and swear, and this time he called heavily upon his vocabulary with the full strength of his powerful lungs. We saw him grab a large bunch of waste from his pocket and use it to close the bleeder, and then descend the ladder with a queer expression on his face.

"That line's charged," he barked. "Some smart Aleck in that repair gang must have a portable lamp grounded on it, somewhere."

"It can't be, Charley," said the boiler-room chief, who had joined us. "They haven't got any lights connected up, yet."

"Well, if you don't think I know when anything is grounded, get up there and bleed that line," snapped McGregor.

"All right. Just to show you that you're mistaken, I'll do that little thing," agreed the fire-room chief, sweetly. Mounting the ladder, he touched the valve very gingerly, in spite of his previous assertions. "See?" he said, as he felt no evidence of "juice" through the valve. "I can touch it without any trouble." And he grasped the valve wheel with his bare hand, and opened it until the steam was once more roaring into the atmosphere.

The nonplussed McGregor shook his head, far from being convinced, although he appeared doubtful of his claims. He wasn't quite satisfied with the way that the boiler-room chief had left the bleeder, and as he had seen the latter open the valve with his bare hand, he once more approached it to adjust the valve to suit himself.

"O-o-o-w-w!" he yelled, as his hand touched the valve, and then the fun commenced. Trembling with surprise and wrath, he again shut the valve with his waste, bounced down from the ladder, and swung around to glare up at the repair gang on the gallery, above.

"You blankety-blank squareheads think you are having a helluva lot of fun, don't you?" he roared, shaking his fist at the stolid-faced Swedes on the grating above him. "Cut it out, now. You've gone far enough."

Those members of the repair crew who understood him took his actions for just another of his frequent pranks, and they grinned knowingly, which incensed McGregor all the more.

We who were on the floor had not fully grasped the reasons for Charley's outburst, but we were enjoying it just the same, and all kinds of suggestions were coming thick and fast from us, to "help him" out of his difficulty.

"I don't want to touch that bleeder again until the ground is removed," he told the first assistant in a trembling voice. The latter could not conceal a smile when somebody in the bunch suggested, "You'd better change your Saturday-night brand of liquid refreshment, Charley."

McGregor's only answer was a glare that ought to have shriveled the speaker to a crisp.

The first assistant was getting impatient to have the work started, so he got up on the ladder, himself, and proceeded to open the bleeder without anything unusual happening.

"Everything feels all right to me, Charley," he said, glancing down, but "Charley" was by that time unable to think or say anything coherent.

Finally, after the steam had been drained off, and the hurriedly summoned electrician had proved that there was not the slightest suspicion of a ground on that pipe-line, we suggested to McGregor that it might have been static electricity produced by the steam jet that had given him the shock. This idea mollified him somewhat, but to this day he suspects that someone in the repair gang knew more about it than anyone else.

Graphic Meters To Record Power Factor

TO CONSUMERS as well as producers of electrical energy the importance of records of power factor is universally recognized. The power factor directly affects the size of conductors, the capacity of equipment, the efficiency of a power installation and the voltage regulation. The correction of low power factor and the resultant economies in power costs, increased production and better voltage regulation can be accomplished only after complete information and accurate records of power factors have been secured. To truly represent conditions records must be taken continuously over a sufficient period of time to include a complete cycle in the operations being performed. In the past records of this character were secured by means of an observer reading indicating instruments and plotting the values on cross-section paper in order to secure a graphic representation of the changes that took place.

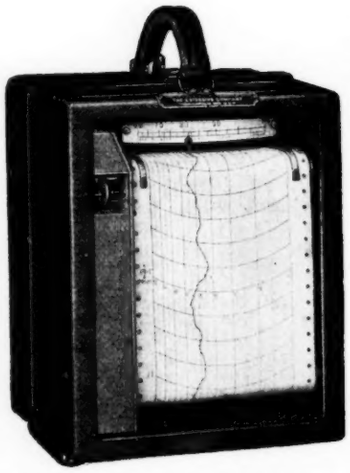


FIG. 1. PORTABLE GRAPHIC POWER-FACTOR METER

Graphic-recording power factor instruments of the portable, switchboard and wall types, made by the Esterline Co., of Indianapolis, are now available. The switchboard type of instrument is intended for permanent installation on switchboards in power plants, substations, and on the properties of large power users having distributing switchboards. The wall type of meter is designed to be mounted on any flat vertical surface to record the power factor of the electrical apparatus to which it may be connected. This type is most suitable for a permanent installation on consumers' premises. The portable instrument, Fig. 1, is compact in design, and by the use of aluminum in the construction of the case and other parts the weight has been reduced to 17 lb. This instrument is especially suitable for general power-survey work, and in making tests on individual motors, groups and complete installations. In all of these instruments the movements are of the dynamometer type, no iron being employed in the magnetic circuits and no inductance or capacity used in the electrical circuits, so that the instruments are free from the effect of varying frequency and wave form. Among the features showing improvements over previous models are the elimination of jewels, pivots and hair springs, a removable pen element, a movement frame molded from bakelite, inclosed nonspillable inkwell and oil damper molded integral with the frame.

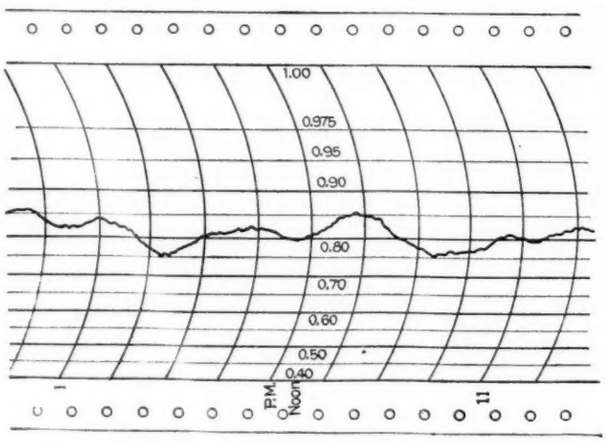


FIG. 2. GRAPHIC CHART OF RECORDING POWER-FACTOR METER

During construction each part of the instrument is subjected to an insulation test of 1100 volts between current-carrying parts and the support, and after the instrument is completely assembled and calibrated it is again subjected to the continuous application of 1100 volts between current-carrying parts and the frame for a period of one minute. An oil damper designed to be nonspillable is provided to damp the movement of the pointer where the characteristics of the circuit make it desirable. A feature to be noticed is that the pen is mounted upon and is actuated directly by the measuring element of the meter, while the ink supply is stationary. This enables the instrument to follow quickly fluctuations in power factor without the use of the usual limiting devices. The entire writing element is carried on knife-edges and can be lifted out for filling and cleaning.

Record charts, Fig. 2, have a ruled portion 4½ in. wide. They are graduated from 40 per cent. power factor at the left-hand edge to 100 per cent. at the right-hand side of the chart, the usual range of power factor encountered coming near the center of the chart. The standard chart speed is 3 in. per hour, but chart speeds of ¾, 1½, 3, 6 and 12 in. per hour can be supplied. When it is desirable to record rapid fluctuations in power factor, minute chart speeds can be supplied by equipping the clock with a rapid chart-feeding device, making available speeds of ¾, 1½, 3 and 6 in. per minute in addition to the regular hourly speeds. The clocks are of the marine, lever type, eight-day movement, contained in dust-tight metal cases.

Instruments with a nominal voltage rating of 100, 200 or 500 volts are furnished. All current coils are designed for a nominal current capacity of 5 amperes. Separate voltage multipliers permit the use of 100-volt power factor instruments on a 200- or a 500-volt circuit, this feature being especially desirable in a portable instrument used on a system having a number of voltages. Polyphase graphic recording power-factor instruments require two potential circuits and one current circuit. When used on circuits having a current capacity exceeding 5 amperes, a current transformer is required, and when the potential exceeds 650 volts two potential transformers should be used.

The most satisfactory way to clean a furnace is the one that is easiest, quickest and most efficient.

EDITORIALS

Efficiency in Our Merchant Marine

WE AMERICANS have appropriated many millions for the construction of a merchant marine. We have started from zero. Once we cut quite a figure in world shipping, but that day has long since passed. One's father was not in the thick of it, but one's grandfather may have been. This gives one an intimate idea of how long ago it was that the Stars and Stripes partly filled the void between sea and sky about the world and how little the present generation of Americans know about the ways of world sea traffic as such knowledge is had from the deck and hold of a ship.

Now if we are to make this enormous investment pay its own expenses, to say nothing of realizing a fair profit, we must do some tall thinking and get some typically American action. The American has a standard of living that makes the rest of the world look like the familiar Sicilian laborer who munches his huge bread loaf and raw onion two paces from the scene of his toil. It will require a considerable part of the operating sum to keep the human side of our ships in good humor and willingly capable. From the standpoint of labor costs we are at a woeful disadvantage with the world.

It must not be imagined that we can make a living carrying the other fellow's goods to the four corners of the world. He has been carrying his own and ours for many years; he is on the ground floor with rates that likely will put ours to shame unless we can outclass him from other directions. And world-beating efficiency in the production of goods shipped in American bottoms must not be called upon to assist in paying the freight. The same ingenuity and engineering that make quantity and quality production of our commodities the wonder and study of the world must permeate our whole shipping activities from the shipyard to the delivery of the cargo.

Fortunately, we are starting from zero. We already have made excellent progress in finding and adopting the most efficient in construction and equipment. The many forces at North Broad Street, Philadelphia, have covered more ground than the public appreciate. We are not, it is hoped, to be burdened with traditional lost motion or prejudice. We lost our hold on the sea because of this very thing. We just pinned our faith to the sail and wooden ship and held aloof from the steel and steam craft until, when we came to our senses, we were hopelessly adrift.

Not the least among the things we must do besides getting construction costs down, is to get operating costs to a competing level. American ships must have a type of boiler that will outclass anything afloat. Not only must it have the most efficient heating surface, but the furnace should be made to produce an efficiency relatively equivalent to that obtained in modern land boilers. This cannot be done with the Scotch boiler. Investigations of combustion and heat transmission in the new Bell Emergency Fleet water-tube boiler and in the first Emergency Fleet boiler, conducted jointly by the Emergency Fleet Corporation and the Bureau of Mines, have shown that with but a few changes in air supply and distribution the combined efficiency may be increased something like eight per cent. above the usual. An evaporation of eight pounds of water per square foot of heating surface is had even at this early stage of experimentation.

Bone's results with surface combustion as well as boiler practice in this country show that combustion volume is of far less importance than provisions for thoroughly mixing the gases of combustion with the air supporting combustion. In land practice large combustion volume is the cheapest way of promoting this mixture. There is not headroom for such volume aboard ship; complete mixing must be had otherwise. And it may be easily and conveniently accomplished—in fact the Emergency Fleet Corporation and the Bureau of Mines engineers already have achieved it.

Hand stoking aboard American ships should be eliminated. Here again these engineers are confident they can develop a suitable stoker. For efficiency in the combustion of liquid fuels, particularly fuel oil, the American naval engineer is the best-versed man on all the seas. He must show our merchant marine how to do it. Here, again, the Bureau of Mines can help greatly with its excellent talent, methods and experience in temperature determinations and its knowledge of heat transfer and the behavior of furnace gases.

There are, perhaps, reasons to believe that it is the training of the human side of these merchant ships that will need closer attention for the longest time. The constructional and mechanical sides are more stable. There does not seem to be grounds for the oft-repeated statement that American young men do not care for the sea. Henry Howard, Director of Recruiting Service, and his colleagues have done some excellent pioneer work in the training of men for our merchant marine. No matter by whom done, or where, there should be maintained some practical organization for this purpose. If we plan superior equipment for ships, we must plan equally well to train the deck and engineer officers and men who will man them.

Metering the Air Supply to the Furnace

NOT long ago, in an editorial commenting on the difficulty of measuring the air supplied for combustion, the statement was made that no satisfactory method has yet been devised whereby a definite quantity of air, by volume or by weight, can be metered on its way into the furnace. It was pointed out that the weighing of the air by automatic scales, as is the case with coal, or the measurement of it in cubic feet, as is the case with feed water, is not feasible.

Exception to this statement has been taken by one of our readers on the ground that it ignores at least one

form of boiler-control apparatus in which the measurement of air flow through the boiler passages plays an important part; and as other readers may have had the same view, it is advisable that we should disclaim any intention to minimize the value of that particular instrument or of any other similar form of boiler-control device.

The apparatus to which our contributor calls attention makes use of the difference of pressure between the furnace and the uptake to measure the rate at which the air flows through the boiler passages, and this rate of flow is graphically recorded on a chart, together with a record of the rate of steam generation. The firing is so regulated as to make the rate of air flow follow closely the demand for steam, on the logical assumption that for every pound of air admitted to the furnace there should be a definite quantity of steam generated under certain predetermined conditions.

In the control of a boiler fitted with a meter of this type, therefore, the object to be attained is an approximate paralleling of the curves recording the rate of steam generation and the rate of air flow. The steam flow is easily recorded in pounds per hour by the use of an accurate meter, but the flow of air is recorded in its relation to the steam flow instead of in pounds or cubic feet.

Just what this relation should be, to obtain the most economical results, is first found by a boiler test and the meter is adjusted accordingly. It will be noted that at no time is the fireman aware of the quantity of air, in pounds or cubic feet, entering the furnace. But by the relative positions of the recorded curves he knows whether too much or too little air is being used, and that is the information that is of importance to him in the management of his fires.

The Evolution of Intensive Power

WE FREQUENTLY hear such remarks as "wonderful power," "tremendous force," etc., and we stand in awe as we contemplate the potentialities of a gigantic hydro-electric plant or a modern central station. A moment's thinking leads to the conclusion that the power itself is not what puts us into this state of mind, but rather what man has done in his effort to harness power and make it work for him. Power has resided in the elements since the dawn of creation. Man's problem since that time has been to find a more and still more intensive means of employing power for his own benefit. The way in which man has mobilized and mechanically ordered the free natural forces from which power is derived arouses our deepest respect and admiration. Power is limited only by the extent to which man uses his constructive imagination. The wooden waterwheel of yesterday is the hydro-electric turbine of today. From the teakettle of Watt has been evolved the two thousand-horsepower boiler of 1919.

In order to permit this development, materials and processes have had to be perfected. The small iron or copper plates of which the haystack boilers of Boulton & Watt were constructed have given place to steel plates of a length, width and thickness the possibility of the production of which Watt could not have conceived. Tubes and pipes laboriously welded by hand over mandrels have paved the way to modern steel tubular products which include diameters from one-eighth inch to thirty inches, and lengths up to forty feet. By the invention of material with high tensile strength and its ingenious adaptation to the lines of force, the eighty-eight feet per second allowable speed of the old flywheel has become the one thousand feet per second of the modern turbine.

Power is the same old servant that it always has been, but man, with his inventiveness and imagination and enterprising spirit, has made it do work that would otherwise have required millions of men and to perform services that it would have been impossible for man to perform

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There is in the ordinary design of boiler setting about four per cent. heat loss through the furnace walls. More than one engineer has wondered why the walls of boiler settings are so frequently made with an air space, because, although the air in the space is a poor conductor, heat from the furnace passes through it rapidly by radiation. Why not make settings solid and cover them on the outside with some sort of insulating material?

Public interest in many industries has been awakened by moving pictures showing processes from raw materials to finished products. A set of films, beginning with the origin of fuel and carried through the construction, erection and operation of a power plant to one of the common applications of power, would afford popular instruction and entertainment, besides stimulating interest in power engineering, of which the average person is woefully ignorant.

Steam-pipe systems should be laid out with care, so that expansion and contraction strains may be taken care of. Notwithstanding this fact one observes numerous instances where pipe lines are rigidly constructed and the expansive force tends to either throw the engine cylinder to one side or to turn the pipe connection at the boiler nozzle. Is it any wonder that there are leaky joints?

A 25,000-kilowatt generator in Chicago is rewound to give 35,000 kilowatts and the hand-fired boilers in another plant are raised several feet and equipped with stokers giving them a hundred per cent. more and badly needed capacity. Talk about intensive farming!

With all the attention welding is receiving these days maybe something besides making welds and pulling them in the old way will be done in an effort to discover a means to determine their strength and character without testing them to destruction.

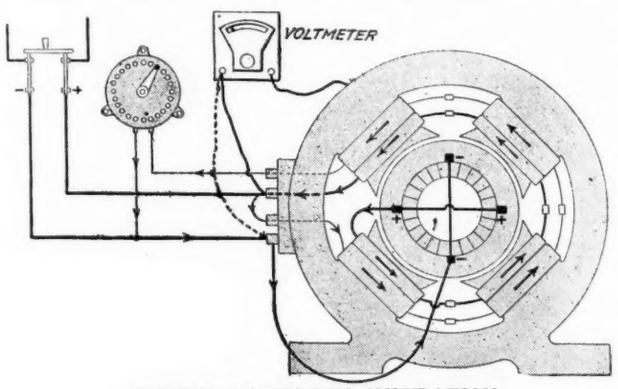
It is foolish to lose sight of the fact that by far the greater number of men in the United States are workers to whom a skilled hand is as important as a well-developed brain.

A rolling stone may not gather any moss, but several engineers are convinced that a revolving turbine rotor can pick up a lot of salt on occasions.

CORRESPONDENCE

Generator Heats Excessively

In the Jan. 21 issue of *Power* Peter Burkard, writing under the title, "Generator Heats Excessively," states that his 160-ampere direct-current generator operates at excessive temperatures when carrying only 90-ampere load. This can happen from a number of causes, but just what does Mr. Burkard mean by excessive temperature? Is it something he considers excessive by the feel of the machine when touching with the hand, or have actual temperature measurements been made and the hottest spots on the winding, as measured with a thermometer, been found to exceed 175 deg. F.? Temperatures that are well within the allowable range feel



METHOD OF TESTING INSULATION

decidedly uncomfortable to the hand. Consequently, machines are sometimes considered as operating at a high temperature, when in fact if temperature measurements were taken they would show that the machine was well within safe limits.

It has not infrequently occurred that the switchboard ammeter indicated that the machine was operating under only partial load, when the truth of the matter was it was overloaded and the ammeter was reading low. Therefore it would be well for Mr. Burkard to check his instruments if he has not already done so. He intimates that the high-resistance brushes might be causing the trouble, although they do not heat excessively. The brushes cannot be the seat of the difficulty or they and the commutator would be the hottest parts of the machine.

If the installation is an old one, high temperature may be caused by current leaks through the insulation. The condition of the insulation may be easily determined by getting the machine up to full voltage and connecting one terminal of a voltmeter to the frame and the other terminal of the instrument to one of the armature terminals and then to the other, as in the figure. In no case should the instrument read more than 3 or 4 volts.

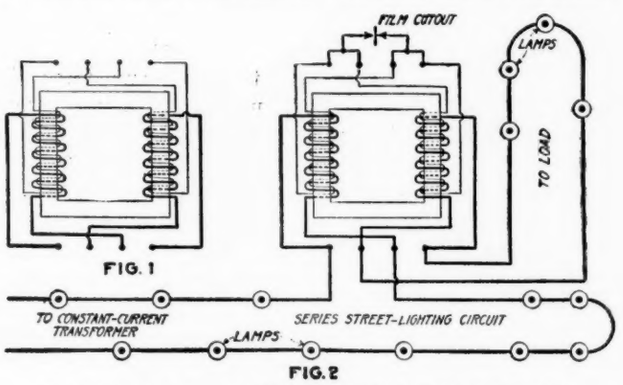
The spacing of the brushes on the commutator may be the cause of the trouble. Unequally spaced brushes often produce heavy circulating currents, especially if the brushes have a low resistance. However, in this case since the brushes are operating at a low temperature it does not appear as though circulating currents caused the trouble. B. A. BRIGGS.

Chicago, Ill.

Constant-Potential Transformer Used as a Series Transformer

At several locations in our series street-lighting system there are series transformers of a 1 to 1 ratio serving as safety coils for special lighting. Several of these transformers have been burned out by lightning, and on account of the difficulty in getting others in time we were forced to rewind the damaged unit in some instances, and in others a temporary substitute was used until new transformers could be secured. The series transformers were insulated to withstand 5000 volts between the primary and secondary coils and also between the winding connected to the high-voltage circuit and the core.

In so far as ratio is concerned, any potential transformer having two coils of a 1 to 1 ratio and of sufficient current capacity can be used as a series transformer, but on account of the insulation requirements between the coils a special selection must be made. No transformer can be used that has the sections of each half of the secondary winding adjacent on the core, on account of low insulation resistance between them.



FIGS. 1 AND 2. POTENTIAL TRANSFORMER AND CONNECTIONS AS SERIES TRANSFORMER

This is to be found in some core-type transformers having a secondary coil subdivided and grouped on the two legs of the core and cross-connected in such a way as to make three-wire operation practical.

For use as a series transformer, I selected an old core-type potential transformer having two 1100-volt primary coils, one on each leg of the core, and located next to the iron. The two 55-volt secondary coils were also located one on each leg of the core and outside of the primary coils, as shown in Fig. 1. The insulation resistance was tested with 10,000 volts between primary and secondary, and primary and core. A test was also

made with 5000 volts between the two sections of the secondary winding and the secondary winding and core.

By using the secondary on one leg of the core as a primary and connecting it into the high-voltage series circuit, and using the secondary coil on the other leg of the core as a secondary and connecting it to the load as in Fig. 2, a series transformer with a ratio of 1 to 1 was obtained. In order to overcome the effect of magnetic leakage on the ratio of transformation when used as a series transformer, the primary coils were connected in parallel, as shown in Fig. 2.

The iron in the regular series transformer was worked at a high degree of saturation, thus making the use of a film cutout in the load side unnecessary. However, in the case of the potential transformer used as a series transformer, the film cutout was necessary on account of the core being worked at a low magnetic density, and there would be a large voltage rise in the high-voltage coils in the event of an open-circuit in the load circuit, which would damage the insulation of the coils. The film cutout was connected in on the high-voltage coils as in Fig. 2.

On account of the weight and cost, such transformers should be used only in an emergency, as in the case in question. The weak points in this equipment are in the secondary bushings and leads, where they come through the case. The bushings should be wiped clean and the leads made to clear one another and also the case, after which no trouble will be found in use up to 5000 volts. For use on higher voltages constant-potential transformers having sufficient current and voltage capacity in the high-voltage coils could be used. The low-voltage coils should be connected in parallel in this case and a film cutout connected across the coil connected to the load. HENRY MULFORD.

Patchogue, L. I., N. Y.

Speed Loss in Transmission

We have several machines that are run from the same lineshaft, all with the same combinations of pulleys, but owing to lost motion or slippage of belts the total output of the different machines varied considerably during the day's run. This caused dissatisfaction among the operators who were on piecework, each wanting the fastest machine.

To equalize the speeds of all the machines, we riveted leather of the necessary thickness on the face of the driving pulleys, equalizing the speed to make the output of each machine the same. C. B. BRUSH.

New York City.

Overheating Hot Water Wasteful

Considerable coal can be saved by the proper regulation of the hot-water supply to buildings. There is no economy in drawing a quantity of hot water and then cooling it by the addition of cold water. About the only thing that real hot water is needed for in hotels, apartment houses, etc., is in kitchens, for washing greasy dishes, etc.

In order to meet these requirements in one building that I know of, all the kitchen sinks were equipped with a steam pipe through which steam can be blown to boil the water. The thermostat on the hot-water tank was then set for about 40 deg. lower temperature than previously carried and there was no complaint from anyone in the building excepting from an old lady who complained that she could no longer make her tea with the hot water. She was advised to get a gas or electric heater because the water would never be kept so hot again. W. T. MEINZER.

Brooklyn, N. Y.

Constant Pressure with Mixed Coal

The accompanying chart is one of many taken from our steam-recording gage on a 150-hp. return-tubular boiler, hand-fired, with natural draft and burning a mixture of hard and soft coal with the proportion of one part of barley to two parts of bituminous coal. It

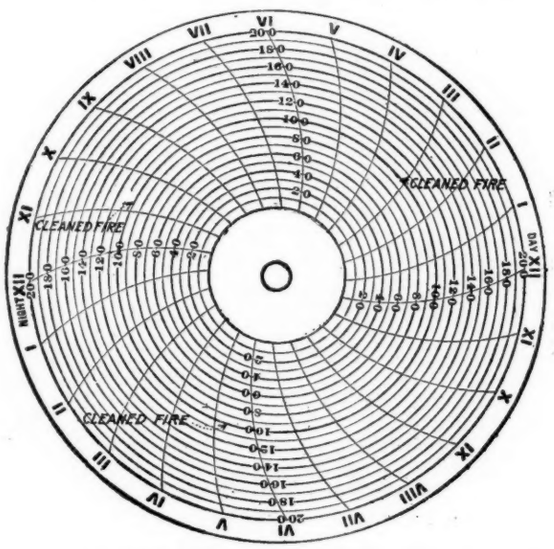


CHART RECORDING HAND FIRING

will be seen that there is no perceptible variation in the steam line except at 3:15 p.m., 10:15 p.m., and 5:15 a.m. The fires were cleaned once on each of the three shifts, the chart being the record of three firemen.

Ventnor City, N. J. E. H. GASKILL.

Testing Cylinder Oils

In reference to Professor Trinks' suggestion in the issue of Oct. 29, 1918, page 644, I have found the steam-engine indicator a splendid instrument for testing cylinder oils. I made this discovery some 12 years ago while conducting some engine tests. I found that straight mineral cylinder oil can be detected with the indicator, as it will cause irregular lines on the diagram. My subsequent experience in seven different plants with quite a variety of engines convinces me that a straight mineral oil will always produce this effect, which is proof of improper lubrication. In one case a chief engineer rejected cylinder oil that contained 5 per cent. of animal oil and accepted a straight mineral oil largely because it cost less than half as much per gallon. This saved about $60 in four months, but injured the engines to such an extent that the service was interrupted a total of over 17 hours in one week and the engineer lost his job. Moreover, it required the expenditure of

$1480 to repair the engines, not including labor, which amounted to perhaps as much more.

Viscosity, fire and many other tests are unsatisfactory when it comes to cylinder oils. A high-grade Pennsylvania stock compounded with about 5 per cent. acid-free animal or tallow oil will keep engines running smoothly and keep the engineer out of trouble. Following are the specifications for an oil that I have used for years with entire satisfaction: Pennsylvania steam-refined cylinder stock, gravity 24.5, flash 586 deg., fire test 665 deg., viscosity 137 at 212 deg., price 65c. per gallon, which includes 5 per cent. clean acidless tallow oil mixed by air agitation.

One contributor suggests that cylinder oils be tested in pumps. I have not found this a satisfactory test, as almost any oil will do for small pumps because the steam pressure and piston speed are usually low and the valves are easy to lubricate, which is seldom true of engines. Low-pressure cylinders will give less trouble if high-grade cylinder oil is mixed with two parts of filtered engine oil. The drips from tail rods can be utilized in this mixture to good advantage.

A frequent cause of difficulty in cylinder lubrication is from rust or sweat corrosion while the engine is standing idle, but the greater part is due to the use of soda-ash boiler compounds or water-softening systems in which an excess of soda ash is used. Soda ash will always destroy cylinder lubrication. Another point seldom given consideration in cylinder lubrication is whether the boilers prime or not, and this is a very important factor in comparing one plant with another. I believe engineers should use more common sense and less fad stuff and snap judgment in the study of lubrication, for what is successful in one plant may not be in another.

WALDO WEAVER.

Franklin, Ohio.

Motor Suddenly Reversed

That a 3-hp. 110-volt shunt-wound motor could reverse under the condition that John R. Steeska describes in the Jan. 21 issue of *Power* seems impossible if the motor has any protection against overloads at all. The speeds given, 2200 to 2800 r.p.m., I take it are the full-load and no-load speeds, which would be a speed variation from no-load to full-load of 21.4 per cent. This is abnormally high for the average commercial machine and would allow the motor to take only approximately 4.5 times full-load current with the armature locked. Even at this, if the motor was properly protected, the protection device should open before the motor could come to rest due to an excessive overload or otherwise.

There are two things that might happen to cause the machine to reverse: First, the field circuit to open with the brushes set back of the neutral (operating with the brushes back of the neutral is a common practice on motors without interpoles); second, the brushes set back of the neutral and the machine subjected to a heavy overload of short duration.

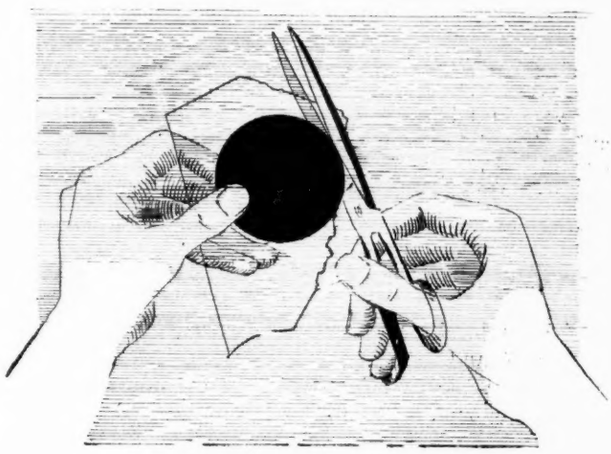
If the armature resistance is as high as indicated by the speed variation from no-load to full-load, the brushes may be set considerably back of the neutral and yet operate satisfactorily. Therefore I feel that the best explanation for this phenomenon is, that a heavy overload was thrown on the motor by someone putting excessive pressure on the buffer, causing the motor to slow down, the brushes being set far enough back of the neutral to cause the armature poles to reverse the polarity of the field poles and reverse the direction of rotation. This of course could not happen if the motor was properly protected.

Another thing that could cause the motor to reverse is, the brush-holder working loose and shifting around the commutator far enough to reverse the direction of the current through the armature. However, this could not occur without the cause of the trouble being discovered before the machine could again be put into service.

New York City. A. A. FREDERICKS.

Cutting Glass Under Water

Cutting a glass dial with a pair of scissors may seem difficult, but it is not, although the job must be done under water and both the glass and scissors must be submerged. A good way is to first cut a paper the size



CUTTING GLASS UNDER WATER

or shape of the glass desired; place it on the under side of the glass for a pattern. It is not expected that it is possible to cut through the center of a large piece of glass, but by trimming a little at a time a good job can be done. The cutting sensation is a good deal the same as that of cutting cardboard.

A. DUBE.

Burke, Idaho.

Boiler Horsepower from Metered Condensation

With reference to the item on "Boiler Horsepower from Metered Condensation" in the issue of Dec. 31, 1918, to which I took exception on Page 101, Jan. 21, my remarks were the result of long and wide experience, and while the editor states that he is always glad to publish discussion letters, I object to the bracketed remarks sprinkled through my comment on the subject quite as much as I would frequent interruptions were I talking on an interesting question. And this subject is of interest to a great many besides the gentleman who originally asked the question, his particular case being covered by my remark that "steam is not gener-

ally sold on the B.t.u. basis," while my opening sentence dispelled any question as to the correctness of the editor's reply and did not ask proofs as illustrated by the fact that I used both the equivalent evaporation figures which you mention and which are known to most engineers before they go to college.

I would like to ask if you, Mr. Editor, have considered the first cost, the installation cost and the maintenance cost of the devices that would be required to sell steam on an accurate B.t.u. basis, and also to have you tell me what to install to sell my steam to tenants and have proofs to combat any disputed charges. Has it not been proved by all the big central steam stations such as the New York Steam Co. that it is impossible to accurately sell steam on a B.t.u. basis? For a basis of calculation consider that I am operating a five-story loft building, that our steam pressure varies from 80 to 125 lb., that we have three 100-hp. boilers, but cannot hold the pressure constant owing to load fluctuations. Would you advocate a recording thermometer on each tenant's return, or on the outlet of each machine where the power of the purchased steam is consumed, or at the inlet, or outlet, of the condensation meter, and where should the meter be placed? Again, would it not be fairer to obtain temperature as it is returned to the point of reconversion?

Your answer to the foregoing will be of great assistance in solving many questions and disputes on the subject and be of interest to two well-known readers of your paper who at present are also very much interested in this subject. THEODORE HAIGHT.

New York City.

Pump Valves Do Not Wear Well

The inquiry by M. C. Larsen on page 30 in the issue of Jan. 7 and the letter on page 101, Jan. 21, commenting on the breakage of rubber pump valves calls to mind a condition that existed in a certain power plant a few years ago. The feed-water temperature varied from about 60 to 212 deg. The cause was that normally the exhaust from the main engines was sold for manufacturing purposes, the condensate being returned at a temperature of approximately 190 deg. and the remainder of the heat necessary to bring it to 212 deg. being supplied by an open feed-water heater that was too small to heat all cold water to that temperature. Consequently, when the supply of hot water was interrupted, which occurred a number of times each day, the feed temperature in winter dropped to about 60 deg. This caused the rubber pump valves to break into small parts, some of which passed over with the feed water and lodged in the 2-in. globe valves used for boiler feeding. As a result these valves required frequent cleaning and on a few occasions caused serious trouble.

As suggested by Mr. Molloy, the solution lay in metal valves, which I installed soon after taking charge. In this case, however, the valves were fitted with a narrow strip of soft composition resembling rawhide, which served equally well for hot and cold water, and were not as likely to leak as all-metal valves. At the time I left that plant, the valves had been in service about two years and had given no trouble whatever.

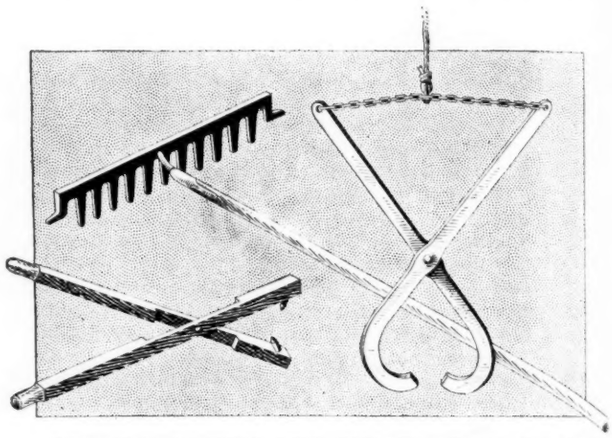
Holyoke, Mass. C. B. HUDSON.

Handy Tools for the Water-Power Plant

Many readers of *Power* are no doubt operators of hydro-electric generating plants and have to contend with various perplexing problems, one of which is the leaf and ice gorge. The leaf gorge occurs at various times, beginning with the first fall of leaves in the autumn and recurring as each "high water" rises to higher levels along the river banks, thus reaching leaves deposited at those levels.

Troubles from ice may be due to surface or cake ice or to frazil or anchor ice. The illustration shows three devices that have proved their worth.

One is a modified rake used for pulling leaves from the trash racks, made by bending the two outside teeth at right angles to the others so that the teeth of the rake are allowed to slip in between the bars of the trash rack only the desired distance, and this distance is made less than that from the outer edge of the rack bar to the bolts that hold the rack together. This arrangement eliminates the chances of the teeth catching the bolts that hold the bars.



HOME-MADE TOOLS FOR WATER-POWER PLANT

Another handy tool is an ice hook that was quickly made in an emergency and serves its purpose admirably. It is used to pull from the racks cakes of ice that would otherwise be difficult to dislodge. It is made of two pieces of wood bolted together as shown. The long ends are used as handles, and in the other ends sharpened spikes are driven. When the ice is too heavy to handle with this device, regular ice tongs are used with a rope to a tackle block.

Richmond, Va. JAMES M. PURCELL.

Conditional Acceptances of Equipment

BY A. L. H. STREET

Plaintiff sold two automatic boiler cleaners to defendant under a contract providing for a 60 days' trial, and providing that if the equipment should prove to be satisfactory the defendant would honor draft for the price 60 days after the installation. It was agreed that if the cleaners should not work satisfactorily the defendant would so notify plaintiff in writing, affording the latter opportunity to make the appliances satisfactory. Defendant gave no intimation of dissatisfaction within the 60-day period. Under these circumstances it is held by the Kansas Supreme Court that defendant's obligation to pay the purchase price became absolute.

INQUIRIES OF GENERAL INTEREST

Varying the Speed of Wound-Rotor Motor—Is it practical to vary the speed in a ratio of 3 or 4 to 1 of a wound-rotor induction motor, by varying the rotor's resistance? T. A.

The speed can be reduced in this ratio but it is not practical on account of the unstable operating condition of the motor at such reduced speeds, and the motor's efficiency will also be very low, since 75 or 80 per cent. of the total energy taken by the motor is expended in the rotor's external resistance.

Wiredrawing of Steam—What is wiredrawing of steam? Can any form of pressure-reducing valve operate without wiredrawing? A. P.

The term "wiredrawing" is applied to the operation of discharging steam through an aperture or passage, but is most commonly employed with reference to a constriction of the flow that results in sudden increase of velocity due to the discharge taking place from a higher to a lower pressure. The very operation of a pressure-reducing valve is to automatically adapt the discharge aperture to the size of opening required for the flow necessary to sustain the desired pressure on the low-pressure side compatible with the difference of pressure. A reduction of pressure of the steam in passing through the valve must be accompanied by velocity due to the difference of pressure, and for any flow to take place there must be some degree of wiredrawing.

Piston Speed of Pumps—What should be the maximum piston speed for pumps of various lengths of stroke up to 15 in.? J. S. M.

The maximum speed without undue slippage is limited mainly by the time required for the valves to seat properly, which depends on the number, type and size of the valves and number of reversals per minute. For pumps of good design, and ordinary ratio of diameter to stroke, the following speeds may be regarded as the maximum for good operation:

PISTON SPEEDS, FEET PER MINUTE

Stroke, Inches	Ordinary Service, Feet per Minute	Boiler Feeding, Feet per Minute
3	40	20
4	50	25
5	60	30
6	65	33
8	75	38
10	80	40
12	90	45
15	100	50

Required Cutoff for Different Initial Pressure—An automatic noncondensing engine 20 x 16 in., running 208 r.p.m., is supplied with steam at an initial cylinder pressure of 90 lb. gage and cuts off at 25 per cent. of the stroke when carrying rated load. What will be the point of cutting off for the same load when the initial pressure is 70 lb. gage? E. J. W.

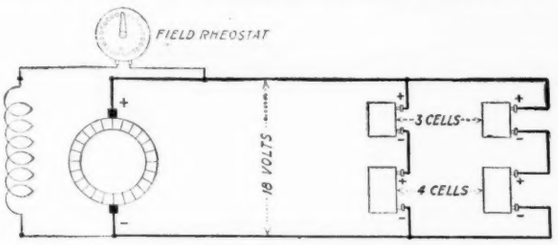
For the same load and speed, the length of cutoff must be appropriate for obtaining the same m.e.p., and that depends on the initial pressure, per cent. of cylinder clearance space and back pressure. The formula for finding the average absolute forward pressure for 1 lb. absolute initial pressure is:

$$P = (1 + log_e R)\ (f + c) - c$$

in which P = average forward pressure per pound absolute; R = ratio of expansion = $(1 + c) \div (c + f)$; f = per cent. of cutoff; and c = per cent. of clearance. Allowing 7 per cent. clearance and 25 per cent. cutoff, the formula would give $P = 0.6359$, and the forward pressure for an initial pressure of 90 lb. gage, which is equal to an absolute pressure of about 90 + 15 = 105 lb. absolute, would be $0.6359 \times 105 = 66.77$. The m.e.p. would be the average forward pressure minus the average back pressure. Assuming, for example, the average back pressure, including compression, to be 30 lb. absolute, the net m.e.p. would be 66.77 − 30 = 36.77 lb. Assuming any different back pressure as 28 lb., in the case of an initial pressure of 70 + 15 = 85 lb. absolute, the average absolute forward pressure would need to be 36.77 + 28 = 64.77 lb., and the cutoff would be at a fraction of stroke giving 64.77 ÷ 85 = 0.762 lb. average forward pressure per pound initial absolute. With this value of P, the value of f in the formula can be found by assuming different values of R. But in place of such a tedious operation, we may turn to a table of mean pressures per pound of initial, with different clearances and points of cutoff, such as given on page 115 of Low's "Steam Engine Indicator," which gives as the nearest an average pressure of 0.7646 for 7 per cent. clearance for cutoff at ¾ of the stroke.

Charging Storage Batteries—Can a small direct-current generator that has a voltage range up to 25 volts be used to charge two 3-cell and two 4-cell storage batteries? R. G.

If the generator has sufficient current capacity without overheating, it may be used to charge the batteries. However, it will be necessary to connect one 3-cell battery in series with a 4-cell battery and connect the two groups



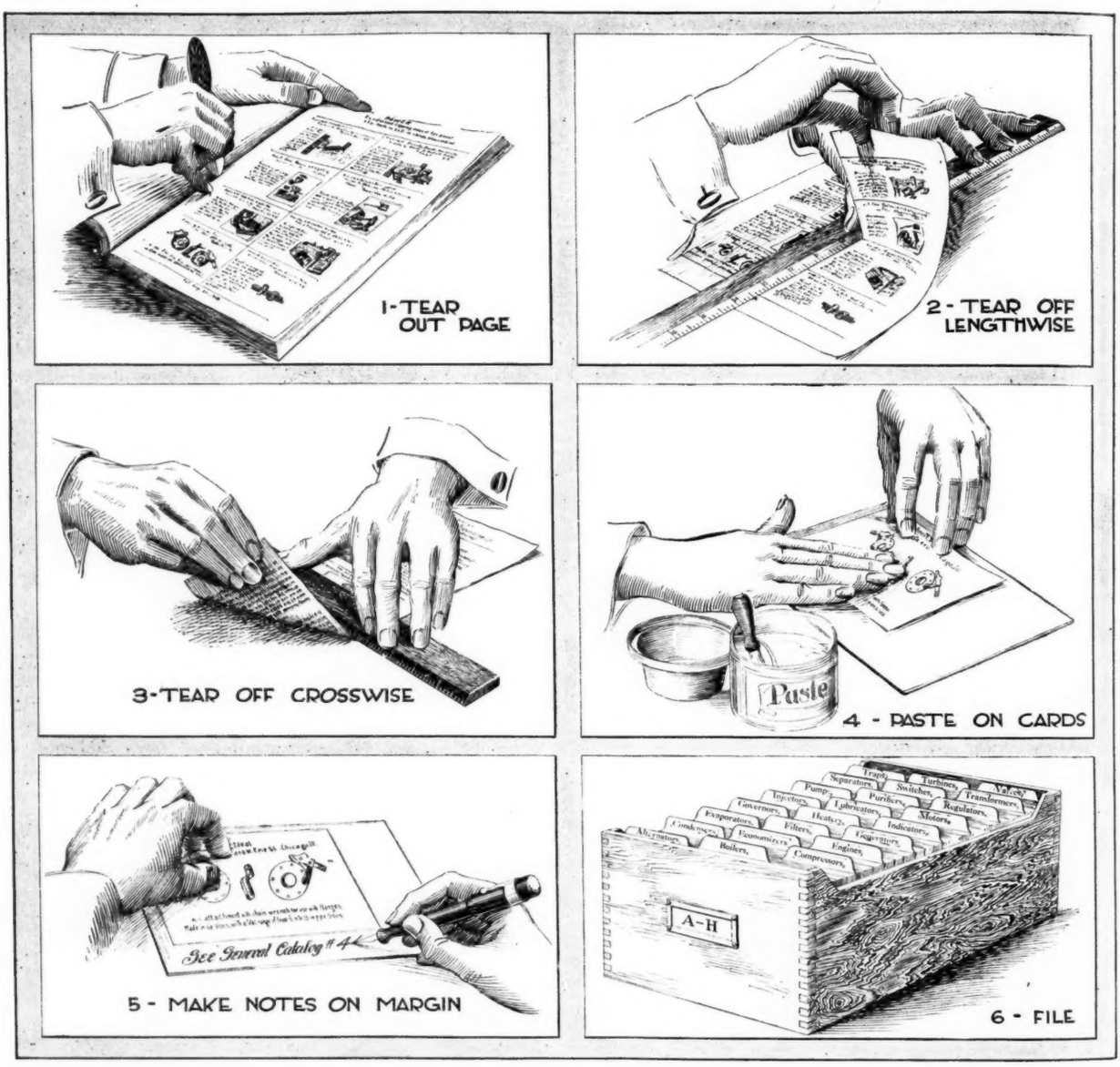
across the generator, as indicated in the figure, or one group may be charged at a time. It will require about 18 volts to bring the groups up to full charge. This voltage can be obtained by an adjustable rheostat in the field circuit, as shown. A group of two 3-cell batteries, connected in series, can be charged alone and will require about 10 volts; a group of two 4-cell batteries connected in series can be charged alone, and will require about 21 volts. The foregoing statements are based on the assumption that the batteries have the same ampere-hour capacity.

Speed of Engine Required to Develop Given Power—What speed would be necessary for a 14 x 16-in. slide-valve engine, with throttling governor, to develop 100 i.hp., if supplied with steam at 100 lb. pressure? E. T.

The highest mean effective pressure, and consequently the most power obtainable, would depend on the design, size and working condition of the throttling governor, the steam-chest pressure realized, the dimensions of the valve, ports and passages, the amount of lead, points of cutoff and compression, as determined by the valve design and setting, and the amount of back pressure on the exhaust. With cutoff at about ¾ of the stroke, 2 to 3 lb. back pressure on the exhaust and enough compression of the exhaust for smooth running, the m.e.p. realized would be about 55 lb. With that m.e.p. the power developed per r.p.m. would be, $\frac{55 \times (14 \times 14 \times 0.7854) \times 1\frac{1}{2} \times 2}{33{,}000} = 0.684$ hp., and to develop 100 hp. would require $100 \div 0.684 = 146.19$ r.p.m.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Introducing the Index of Equipment



ON THE opposite page is an innovation in technical literature that will be a valuable aid to every man who has to do with power-plant equipment. It preserves for permanent record, in standardized form, a classified and illustrated history of progress in power-plant apparatus; a record that will gain in value in rapidly increasing measure as the weeks go by.

The superintendent and the chief engineer who look for the last word in power-plant apparatus will find in this an index of all the new machines and instruments available for obtaining economy—and find them instantly. There will be no need of going over back issues of *Power*.

The designer who must keep in touch with progress will find in this clipping index a complete summary of new developments.

Everyone interested in power-plant apparatus has in this index a centralized directory of "What is What" in new equipment for their requirements.

Patent lawyers will use this index as an indisputable evidence of priority, since the date of publication is printed on each item. Consulting engineers will welcome a perpetual record with such flexibility of filing.

Technical schools and colleges will appreciate the value of a continually up-to-date textbook on the important subject of power-plant equipment.

The method of utilizing this information is clearly indicated in the illustration. Separate individual descriptions, paste them on a 3 x 5 in. card, and file as desired. Heads for alphabetically filing can be taken from the Power Buyers' Cyclopedia.

Power is glad of the opportunity of presenting this accomplishment to its readers.

The water power committee of the British Conjoint Board of Scientific Societies has come to certain conclusions, one of which is that the development of the Empire's natural resources is inseparably connected with that of its water power, says the *Engineer*. It estimates that the Empire's water power is from fifty to seventy million horsepower. The Canadian branch of the committee showed that Germany had utilized her water power most (43.4 per cent. of the world's water power), Great Britain only more than Russia, which has done least (8.3 per cent.) in this direction.

Condensed-Clipping Index of Equipment

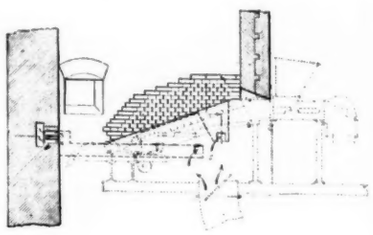
Clip, paste on 3 x 5-in. cards and file as desired

Furnace Construction, Bernitz.

Bernitz Method Co., Tremont, Tremont Bldg., Boston, Mass.

"Power," Dec. 17, 1918

Designed to prevent the formation of clinkers on boiler-furnace side walls and on bridge walls. System consists of an arrangement of firebrick in the furnace walls whereby air is admitted between the bricks of the side setting and at the bridge-wall into the fuel bed. Air is supplied by means of forced draft through suitable ducts and is controlled by a damper.

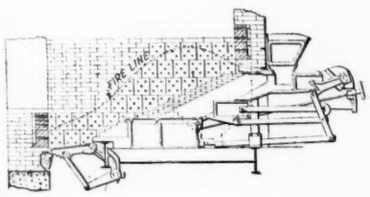


Furnace Blocks, Drake Non-Clinkering.

Sleicher & Drake, 5 Beekman St., New York City.

"Power," Feb. 4, 1919

A system whereby air is admitted to the boiler furnace along the fire line at the side walls and bridge-wall through tapered air holes in specially designed firebrick blocks. An air duct is formed at the back of the block and is run to a windbox. A damper controls the air supply to the air duct. The object is to prevent the formation of clinkers on the furnace setting.

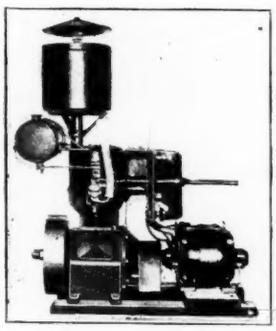


Plant, "Alco" Power and Lighting

Automatic Light Co., Inc., Minneapolis, Minn.

"Power," Jan. 21, 1919

Consists of a single-cylinder four-cycle water-cooled engine directly connected to a direct-current generator. Duplex wound, 110-volt power and lighting circuit; 7½-volt on starting and battery charging. Unit stops automatically when current is not being used.

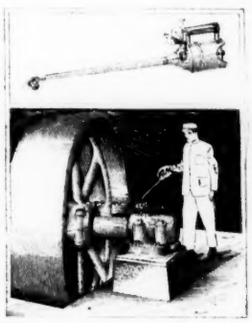


Oil Can, Bateman Illuminated

William G. Bateman, 154 Lackawanna Ave., East Stroudsburg, Penn.

"Power," Jan. 14, 1919.

Consists of a battery, electric light and wiring attachment. Pressing a lever closes the electric circuit and the light at the end of the oil-can spout illuminates the point to be lubricated. Light can be dispensed with when not needed by throwing back lever.

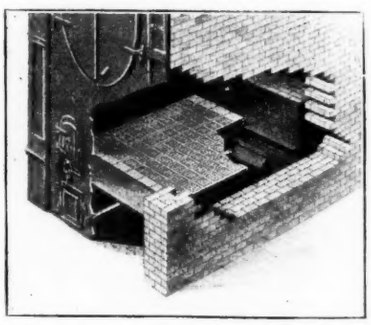


Furnace System, Carrick.

Carrick Engineering Co., 538 South Clark St., Chicago, Ill.

"Power," Dec. 24, 1918

Grates are made with air passages oblique and nozzle-shaped, so that a multitude of separate streams of air travel through them to the fuel bed. Air is supplied through a duct leading to the ashpit, the supply being regulated by a damper.

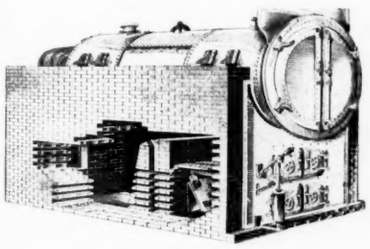


Smoke Preventer, Kosel.

Henry G. Kosel, 405 E. 168th St., New York City.

"Power," Jan. 21, 1919

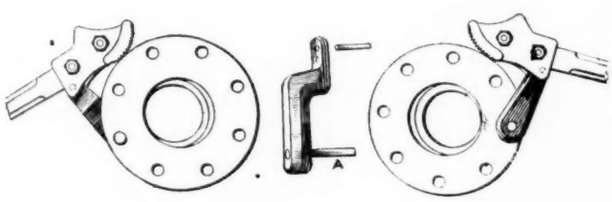
Bridge-wall of furnace supplemented by a second one and so arranged that an air space is left between them. The opening at the top of the bridge-wall directs the air toward the combustion chamber and thus assists in the combustion of furnace gases. Air enters the bridge-wall air space from the ashpit. Air volume is controlled by a damper and a plunger in a cylinder containing glycerine or oil.



Flange Attachment, Ideal

Kroeschell Bros. Co., 440 W. Erie St., Chicago, Ill.

"Power," Jan. 14, 1919



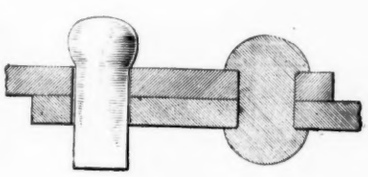
An attachment with chain wrench for use with flanges. Made in six sizes, with a total range of from 1¼-in. to 20-in. in pipe sizes.

Rivet, American

American Flexible Bolt Co., Pittsburgh, Penn.

"Power," Dec. 31, 1918.

Rivet is designed with the head but partly formed. As the head is finished when driving, the metal is forced to flow into the opening between the shank and the plate, thus making a tight rivet. But one stock of each size is required as the head in driving can be formed to any desired shape.



Patented Aug. 20, 1918

Declining Supply of Motor Fuel

The Society of Automotive Engineers, at its recent annual meeting, devoted an entire session to discussion of the fuel question. This session was arranged at the suggestion of Dr. Joseph E. Pogue, of the Bureau of Oil Conservation, United States Fuel Administration, who presented a paper entitled "An Interpretation of the Fuel Problem." In this paper he pointed out how rapidly the demand for engine fuel has been increasing and will shortly exceed the available annual supply, although domestic production is about 340,000,000 bbl. and 60,000,000 bbl. are imported. He stated that about 20 per cent. of the crude petroleum is being converted into gasoline. This percentage can be increased by employing more modern refining methods, but not without increasing the price. The stock remaining will naturally become heavier all the time, and the yield of gasoline is thus bound to decline, so that finally not more than 2½ per cent. can be reclaimed as gasoline.

The blending of high-volatile gasoline made from natural gas with low-volatile refinery gasoline is widely employed, but the quantity made available by this method is relatively small. By lowering the volatility of the gasoline through the use of a larger percentage of the volatile petroleum such as kerosene, the supply of engine fuel can be increased, but not indefinitely or without disadvantages. The great objection to this plan is that existing types of automobile engines are not adapted for burning the heavier oil.

The hope of obtaining adequate supplies from Mexico he believed to be ill-founded because the extent of supply was an uncertain factor, and the ships of Great Britain and the United States are already drawing heavily on Mexican oil. Moreover, the heavy Mexican crude has low gasoline content. Substitute fuels, such as benzol, alcohol and shale-oil distillate may well be considered and may have to be adopted ultimately, but their price will necessarily be greater than that of gasoline today, because of high manufacturing cost. The retail price would reach 50 or 60c. per gallon.

The two possible (and perhaps temporary) solutions of the problem are: The more intensive refining (or "cracking") of the crude petroleum, with its necessarily greater cost per gallon and the development of engines capable of utilizing fuel less volatile than gasoline. A third item that will help to alleviate the situation is to build engines whose consumption is less than that of the average present-day engine, but not without adding machinery, expense and complications. Dr. Pogue sums up the situation as follows:

1. The automotive industry can no longer afford to ignore the engine-fuel problem.
2. The supply will positively decline, and the price will rise without our being prepared for it.
3. The burden falls upon the engine. It must adapt itself to less volatile fuel and should be made to burn oil with less waste.
4. To accomplish these results is the task put before the Automotive Engineers, who must study the petroleum, keep the industry informed and conduct researches with a view to averting an otherwise great calamity which would seriously disorganize an indispensable system of transportation.

Dr. David White, Chief Geologist of the United States Geological Survey, presented at this meeting an authoritative statement of American petroleum resources. His paper, entitled "The Unmined Supply of Petroleum in the United States," represents the result of elaborate investigations into the quantities of oil used and still available in the various producing districts of this country.

To satisfy public interest, the Government has had four estimates made of the oil resources of the United States. The latest of these places the oil available in the ground at the end of 1918 at 6,740,000,000 bbl. The total output of oil in the United States in 1917 was 335,315,601 bbl., and in 1918 probably 345,500,000 bbl. The total production from 1858 to date is estimated at 4,598,144,000 bbl. To supply our demand in 1918, 27,000,000 bbl. had to be taken from storage, and in addition, 31,000,000 bbl. was imported from Mexico. The deficiency in current production during 1918 was therefore 58,000,000 bbl. A continuation of the consumption curve indicates for 1919 a consumption beyond the 400 million mark (it was 397 million in 1918).

Dr. White fears that Mexico has less oil under ground than the United States. But he holds out the hope that processes may be developed which will permit of extracting oil on a commercial and economical scale from the great deposits of shale that exist in Colorado, Utah, Wyoming and Nevada. These deposits of oil shale three feet in thickness are capable of yielding 25 gal. of oil per ton of rock, or a total of 75 billion barrels. In this case the gasoline content would be about 12 per cent. Hydrocarbon engineers and chemists are expected to conduct the necessary researches leading to a utilization of the oil shales before the supply of petroleum from other sources declines too far. Immense distilling plants will be necessary to treat the millions of tons of shale rock, and to develop and construct these will require the expenditure of much time and capital.

Comparison of Steam Engines and Gas Engines

Late in 1918 a Congress of Civil Engineering was held at Paris, at which Mr. Compère, manager of the Parisian Association of Steam Boiler Proprietors, presented a paper dealing with the status of motive power in France at present. In it he observed that the operation of a gas producer demanded closer attention than did a steam engine. To this statement R. E. Mathot took exception, on the ground that it was unfair to compare the producer to the steam engine and that it should be properly compared to the steam boiler. In the latter case the producer had the advantage, as it needed to be fed with fuel every three hours and cleaned once a day, whereas a boiler needed frequent firing and cleaning of fires.

To the statement of Mr. Compère that the producer-gas engine worked faultily because of the varying proportions of steam and air admitted to the producer, Mr. Mathot replied that it was true enough as applied to obsolete designs, but that in modern plants the steam and air were automatically regulated. He admitted that keeping the fire-doors open too long might affect the power of the engine when working under full load, but he pointed out that in a steam boiler a drop of pressure would result from the same cause, and consequently a decrease of power of the steam engine, if it were overloaded. He emphasized the fact that the skill of the attendant affected the economy of the producer little, if at all, but that the economy of a steam boiler depended almost wholly on the stoker.

Mr. Compère quoted a statement to the effect that in a factory using uniform power ten hours a day, a gas engine would be advantageous up to 200 hp., but that with variable load conditions a good up-to-date steam plant would consume less fuel from 30 to 40 hp. up. Mr. Mathot objected to this statement and insisted that there was no example of a modern gas-power plant that consumed more than 1.5 to 1.7 lb. of anthracite per horsepower-hour, whereas a steam plant of even an improved design would use 3 to 4 lb. of coal of equivalent value. On the basis of a normal load of 200 hp. the comparison would be favorable to the gas producer because it could show an economy of 1 lb. of coal per brake horsepower-hour as against 2 lb. in the steam plant.

It was argued that a producer run during the day kept on consuming coal during the night, but Mr. Mathot contended that this was equally true of the steam boiler that is banked and that much more fuel would be required to hold the fire and raise steam in a steam boiler than in a producer. He stated that a 200-hp. boiler would require about 150 lb. of coal for banking and at least 200 lb. to come up to working pressure in the morning, whereas a 200-hp. producer would require only about 40 lb. of coal and the use of the blower for a quarter of an hour at starting.

United States Employment Service

For the first time in the history of America's development, employers have an opportunity of selecting from a large and varied list of highly educated and experienced men those individuals especially equipped to meet their particular requirements.

Engineers, executives, men of college training and practical experience in business and technical fields are now being released from the Army, Navy and war work. The Professional and Special Section of the United States Employment Service, a branch of the Department of Labor, has been organized for the benefit of employers in need of these men. The service is entirely free of charge.

The organization already has thousands of well-educated, experienced men on its lists and is daily placing many of them in touch with employers. I. W. Litchfield, the head of the Professional and Special Section, was one of the organizers and directors of the United States Public Service Reserve, which supplied high-grade engineers and business men to the Government for war work.

The Employment Service is now divided into two great zones for the purposes of the professional and special section. The New York office, headquarters for the Eastern Zone, at 16 East 42nd St., is in charge of the following states: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Ohio, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida and Alabama. The Chicago office, headquarters for the Central Zone, at 63 East Adams St., is in charge of all remaining states. Later zone offices will be established to take charge of part of the territory now in the Chicago Zone.

The Service is now represented in each of the forty-eight states by a head office under the immediate jurisdiction of the Federal Director for that state. All local community labor boards are responsible directly to the Federal Director in their work of placing skilled and unskilled labor. The office of the Federal Director is particularly charged, however, in filling requisitions from employers for the highest type of business, professional and technical men. This class of men are registered only in the Professional and Special Section. In case the office of the Federal Director for a particular state cannot supply the high-grade man required by an employer, the requisition for that man is forwarded at once to the zone office to which that state is responsible. Likewise, the applications of men qualified for important positions are forwarded through the same channels.

The United Engineering Societies, composed of the four great engineering organizations—American Society of Mechanical Engineers, American Society of Civil Engineers, American Institute of Electrical Engineers and American Institute of Mining Engineers—are now coöperating with the Professional and Special Section in placing men in the engineering professions. The high standards maintained both by the Government organization and by the societies has proved to be of the utmost benefit to employers as well as to experienced engineers seeking employment.

The employer should at once get in touch with the office of the Federal Director in his state or write direct to either the New York or Chicago Zone offices. It is important that the employer give complete and specific details of the position to be filled, together with the maximum and minimum salary he is willing to pay. These details are regarded as confidential by the Government and are withheld from the applicant.

New Publications

STEAM ENGINES. By E. M. Shealy, associate professor of steam engineering, University of Wisconsin. Published by McGraw-Hill Book Co., 239 West 39th St., New York. 6 x 9 in.; 290 pages; 173 illustrations; cloth. Price, $2.50.

This is used as a textbook for correspondence students in the University of Wisconsin Extension Division and is an excellent treatment of the subject for operating engineers. The fundamental principles underlying the operation of the steam engine are presented in as simple and non-mathematical manner as possible. Enough of the practical features of steam-engine design, construction and operation are given to illustrate the principles and in such a manner that operating engineers will be able to supplement other applications of the principles presented. That part of the work dealing with valve gears has been made more complete than other sections, and to good purpose, because operating engineers usually do not understand the valve-gear mechanism of their engines as well as other parts. The work is divided into 20 chapters under the tities: Principles of the Steam Engine; Corliss and Other Engines; Parts of the Steam Engine; Heat, Work and Pressure; Properties of Steam; Indicators; Indicated and Brake Horsepower; Action of Steam in the Cylinder; Steam-Engine Testing; The Slide Valve; The Valve Diagram; Valve Setting; Shifting Eccentric and Meyer Valve; Reversing Mechanisms; Corliss Valve Gears; Governing; Compound Engines; Condensing Apparatus; Lubrication; and General Principles of Steam Turbines.

FUEL FACTS

The United States Fuel Administration has issued a second revised edition of "Fuel Facts," which contains valuable information for consumers and savers of fuel. A copy may be had by applying to the U. S. Fuel Administration, Washington, D. C.

Personals

J. V. Henderson, who until recently was associated with the firm of Pratt & Henderson, power-plant specialists, has been appointed chief engineer of the Hotel Statler, Detroit.

L. C. Vincent, for the last six years master mechanic at Wilson & Co.'s Oklahoma City plant, has taken a position as chief engineer of the Steffens-Brecht Creamery Co., of the same city.

Donald D. Davis, a man of practical engineering, accounting and factory executive experience, has been appointed to conduct an industrial department which has been established by the Liberty National Bank of New York for the purpose of offering its services in an advisory capacity on matters pertaining to manufacturing and industrial problems.

Engineering Affairs

The American Institute of Electrical Engineers will hold its seventh midwinter convention in the Engineering Societies Building, 33 West 39th St., New York City, Feb. 19-21.

The Detroit Engineering Society will hold a joint meeting with the Michigan Chapter of the American Society of Heating and Ventilating Engineers on Feb. 21. L. D. Royer, of the Power and Construction Department of the Ford Motor Co., will talk on "The Measurement of Flow of Liquids and Gases by Means of the Pitot Tube."

The American Electric Railway Association will hold its first midyear meeting and dinner since the entry of the United States into the war, in New York City on Mar. 14. The meeting will be held in the morning and afternoon in the Engineering Societies Building, 29 West 39th St., and the dinner in the evening in the grand ball room of the Waldorf-Astoria hotel.

Miscellaneous News

The New Jersey State Board of Boiler Rules met at Newark, N. J., Feb. 13 and adopted the recent revisions of Part I, Section I of the A. S. M. E. Boiler Code for construction of power boilers, which was reviewed, pages 196-198 of Feb. 11 issue of "Power," and the revision of Part I, Section II for construction of heating boilers, reviewed page 236 of this issue.

The Massachusetts Board of Boiler Rules, which held its semi-annual hearing on proposed changes on Nov. 7, 1918, has changed Rules 2 and 3, Part III, Sec. 1, so as to allow 0.035 per cent. instead of 0.03 per cent. of phosphorus (basic) in fire-box steel used in the construction of boilers. This now accords with the limit adopted by the American Society for Testing Materials and the Code of the American Society of Mechanical Engineers. The composition of extra-soft steel remains as before. This law becomes effective about July 1, but on application to the Board can be taken advantage of on receiving its permission. One boiler manufacturer has secured this permission in advance. A petition by a valve manufacturer that safety valves be allowed of the beveled-seat type only, was withdrawn without action by the Board.

Business Items

The August Mietz Corp. has moved from 424 East 19th St. to 310 East 19th St., New York City.

The Underfeed Stoker Co. of America has moved its general offices from the Harris Trust Building, Chicago, to the Book Building, Detroit. The Chicago quarters will be retained, however, as a district sales office.

The Joseph L. Sheldon Engineering Co. has moved into its new location at 238-242 Water St., Toledo, Ohio, where a thoroughly equipped machine shop has been fitted out and a full line of power plant machinery will be in stock. This company has recently taken over the entire output of the McNaull Boiler Co. of Toledo, and will shortly establish district representatives in all the principal cities.

Trade Catalogs

The Brown Hoisting Machinery Co., Cleveland, Ohio, has just issued its 96-page illustrated Catalog K for 1919, 8½ x 11 in. A complete book of information on "Brownhoist" locomotive cranes.

The Coppus Engineering and Equipment Co., Worcester, Mass., has issued a bulletin covering its Type CCC Coppus centrifugal turbo boiler-feed pump, and clearly describing its advantages. A copy may be had free upon request.

The Steere Engineering Co., of Detroit, Mich., has just issued its Bulletin No. 36 on "Plant Models." It illustrates the practical methods employed by this company in analyzing and determining plant requirements. A copy of the bulletin may be had free upon request.

New Construction

PROPOSED WORK

N. Y., Far Rockaway—The Far Rockaway Strand Theatre Co., Strand Theatre Bldg., New York City, plans to install a steam heating system in the 1 story, 44 x 250 ft. theatre which it plans to build on Central Ave. here. Total estimated cost, $100,000.

N. Y., New York—The Pictorial Review Co., 222 West 39th St., will install a steam heating system in the 12 story, 107 x 147 ft. printing plant which it plans to build on 7th Ave. and 39th St. Total estimated cost, $1,000,000. Address H. Goodstein, Representative.

N. Y., New York—R. B. Smith, Consulting Engr., 50 East 42nd St., is in the market for 1 shape furnace and one plate furnace with 2 motor driven blowers, one hydraulic ram, 8 forge fires and one 1000-lb. steam hammer.

N. Y., Wards Island—The State Hospital Commission, Capitol, Albany, will receive bids until March 4th for the installation of a heating plant and sanitary electric work in the 3 story, 22 x 114 ft. building which it plans to construct at the State Hospital. Total estimated cost, $100,000.

N. J., Union Hill—The Board of Education plans to install a steam heating system in the 3 story, 100 x 190 ft. school building which it plans to construct on Hudson Ave. Total estimated cost, $250,000.

Penn., Allentown—The city plans to build an electric-light plant, to be operated in connection with the city water-works pumping station. H. T. Bascom, City Engr.

Penn., Harrisburg—The State Board of Health plans to build a new electric power plant at the Mount Alto Sanatorium.

Penn., Hawley—The Welewood Silk Mills plan to build a hydro-electric plant. W. F. Suydam, Mgr.

Md., Baltimore—The Building Committee of the Seventh Baptist Church, North Ave., and St. Paul St., plans to rebuild the church recently destroyed by fire. A steam heating plant and electric lighting system will be installed in same. Total estimated cost, $100,000. Address C. N. Friz, 14th floor, Lexington Bldg.

Md., Golden Hill—W. F. Applegarth will install a 75 h.p. steam boiler and a 25 h.p. engine in the 1 story, 80 x 175 ft. tomato canning factory which he plans to build. Total estimated cost, $5000.

Md., Hagerstown—The Board of Education of Washington Co. plans to build three 2 and 3 story school buildings, 1 at the north end of the city, addition to 1 on Antietam St. and 1 at Halfway. Steam heating plants will be installed in same. Total estimated cost, $200,000. A. K. Klinkhart, 27 West Washington St., Arch.

Fla., Pensacola—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install electric equipment at the Naval Air Station, here. Estimated cost, $30,000. Specification No. 3785.

Fla., Starke—The city plans to issue bonds for improvements to its power plant. Address the Mayor.

Miss., Hollandale—Bids will be received until April 8th by the Black Bayou D.D., Washington Co., (Greenville), for the construction of a 1 story pumping plant house and dam near here. Estimated cost, $17,000. Morgan Engineering Co., Goodwyn Institute Bldg., Memphis, Tenn., Engr.

Tenn., Memphis—The Board of County Commissioners plans to install a new electric-lighting plant in the local court house. Estimated cost, $10,000.

Ohio, Cleveland—The Board of Education, East 6th St. and Rockwell Ave., plans to install a steam heating and ventilating system in the 1 story school building which it plans to construct on East 146th St. near Kinsman Rd. Total estimated cost, $200,000. W. R. McCornack, East 6th St. and Rockwell Ave., Arch.

Mich., Detroit—The Monroe Sheet Metal & Roofing Co., 563 Myrtle St., will install a boiler, engine and generator in the factory which it plans to build on Pine and 5th St. Smith, Hinchman & Grylls, 710 Washington Arcade, Arch.

Mich., Detroit—The Water Board has submitted plans to the City Council for building and equipping a boiler house. Estimated cost, $439,600. G. H. Fenkell, Ch. Engr.

Mich., Detroit—The Board of Education plans to alter and improve the heating and ventilating systems in the Eastern High School building on Boulevard and Mack Ave. Estimated cost, $10,080.

Ill., Chicago—The Bankers Supply Co., 2251 South Park Ave., will install a steam heating plant in the 1 story, 100 x 370 ft. printing plant, which it plans to build on State St., near 59th St. Estimated cost, $120,000. R. E. Pingree, 209 South La Salle St., Arch.

Ill., Chicago—The Ohio Match Co., Wadsworth, Ohio, plans to install a steam heating system in the 8 story, 100 x 124 ft. warehouse, which it plans to build here. Total estimated cost, $200,000. R. H. Hinsdale, 527 Erie Bldg., Cleveland, Ohio, Arch.

Wis., Eau Claire—The International Toy Co. will construct a separate transformer station in connection with the 60 x 300 ft. plant which it plans to build. L. D. Pangborn, Mgr.

Wis., Milwaukee—The Milwaukee Paper Box Co., 400 Florida St., plans to install a steam heating system in the 5 story, 120 x 145 ft. paper box factory which it plans to build on South Pierce and Muskeg St. Total estimated cost, $225,000. Address Schnetzky & Son, Arch., 105 Wells St.

Wis., West Allis—The Common Council plans to build an electric light and power plant. J. Sweet, 521 Grand Ave., Milwaukee, Consultg. Engr.

Iowa, Sioux City—The Commissioners of Woodbury County are having plans prepared by W. Steele, Arch., 502 United Bank Bldg., for the construction of a 2 story, 60 x 180 ft. home on Bronson Rd., E. Plans include the construction of a separate building for heating, generating and water supply and equipment for same. Total estimated cost, $100,000.

Minn., Le Sueur—The city will receive bids until Feb. 21st for a 150 h.p., 150 lb. pressure tubular boiler, also a 200 h.p., 150 lb. pressure tubular boiler (only one boiler will be purchased).

Minn., Virginia—The city will install a steam heating plant, and mechanical ventilating system in the 3 story city hall and public auditorium which it plans to build. Total estimated cost, $200,000. A. E. Bickford, City Clk.

Kan., St. John—The city plans an election in April to vote on bond issue to build a new power house for the water and light departments.

Kan., Topeka—The State Legislature has approved the appropriation of $12,000 for stokers at the power plant and $10,000 for improvement to the water system, steam heating and electric plants for the Topeka State Hospital.

Neb., Omaha—The Overland Tire & Rubber Co., 917 Woodmen of the World Bldg., plans to build a power plant to develop 2500 h.p., in connection with the rubber and tire factory which it plans to construct on 36th St. and Belt Line Ry. Total estimated cost, $150,000.

Mo., Butler—J. F. Kern plans to build an electric light and power plant and is in the market for machinery for same.

Mo., Carrollton—The Water, Light & Transit Co. plans to improve its plant. Estimated cost, $3000. H. W. Graham, Mgr.

Mo., St. Louis—The Anheuser Busch Brewing Association, 9th and Pestalozzi St., plans to equip the second unit of its bevo plant, and is in the market for electric motors, elevators, power equipment and bottling machinery. H. Menzenwerth, Supt.

Tex., Aransas Pass—The France & Canada Oil Transport Co., 120 Broadway, New York City, N. Y., plans to establish an electric-light plant here.

Tex., Ft. Worth—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to build a 1 story boiler and pump house transmission line and electric distribution system, in connection with the argon production plant which it plans to build at North Ft. Worth. Total estimated cost, $607,250.

Tex., San Antonio—Fire recently destroyed the plant of the San Antonio Public Service Co., Villita and South Presa St., entailing a loss of $25,000.

Okla., Woodward—The city plans an election in February to vote on a $30,000 bond issue which will be used to equip the water and light plant.

Colo., Breckenridge—The city plans to build an electric light plant.

N. M., Valedon—The Eighty Five Mining Co., Lordsburg, is in the market for a 1000 h.p. boiler, a 1000 h.p. steam turbine and steam equipment.

Ariz., Tempe—The city plans election soon to vote on bond issue for the construction of a gas and electric-light plant.

Ore., Astoria—The Commissioners of the Port of Astoria plan to sell $750,000 bonds for various improvements at the port, to include enlarging power plants for the city.

Cal., Sacramento—R. Carstensen, 35th St. and 5th Ave., has had plans drawn for the construction of a cold storage and ice manufacturing plant on R St., between 16th and 17th St. Estimated cost, $225,000.

Que., Montreal—The Department of Public Works, Ottawa, Ont., plans to appropriate $1,000,000 for the construction of a cold storage plant here.

Que., Montreal—The Stinson-Reeb Builders Supply Co., 45 St. Alexander St., is in the market for a portable locomotive or upright type boiler, 25 to 35 h.p.

Que., Quebec—C. J. Rockwell, 7 Des Erables Ave., recently purchased the Rattray Block from the "La Compagnie d'Angarage de Quebec, plans to build a first class cold storage plant.

Ont., Owen Sound—W. Kennedy & Sons, Ltd., is in the market for a 15-ton electric traveling crane, 39 ft. 10 in. span, 3 motor, 60 cycle, 550 volt, to be installed in plant recently erected.

Ont., Toronto—A. W. Adams, 55 West Lodge Ave., is in the market for a 500-h.p. engine.

CONTRACTS AWARDED

R. I., Providence—The Revere Rubber Co., 355 Valley St., has awarded the contract for the construction of a 1 story, 52 x 90 ft. boiler house on Hemlock St., to the Cruise & Smiley Construction Co., 12 East Ave., Pawtucket. Estimated cost, $30,000.

N. Y., Wards Island—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for installing refrigerating plant equipment at the Naval Hospital Reservation here, from the Vilter Manufacturing Co., 872 Clinton St., Milwaukee, Wis., $20,935, (90 days); Frick Manufacturing Co., West Main St., Waynesboro, Penn., $21,074 (93 days); Mayer Ice Machine & Engineering Co., 315 Grant Ave., Jersey City, N. J., $21,192 (60 days).

Penn., Philadelphia—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a water power pump and tank house, at Grays Ferry Rd., to M. H. McCloskey, Jr., 1620 Thompson St., at $15,567 (90 days).

Md., Baltimore—The War Department, Washington, D. C., has awarded the contract for installing heating plants in 5 additional buildings at General Hospital No. 7, here, to the Enterprise Steam & Hot Water Heating Co., 600 North Howard St.; electric work to the Brueckmann Electric Co., 501 Keyser Bldg.

D. C., Anacostia—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing a heating system in the hangar at the Naval Air Station, to L. E. Breuninger, Colorado Bldg., Washington, at $10,625 (75 days). Noted Feb. 11.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for installing mechanical equipment and piping for the central power plant at the Naval Operating Base, (a) net price and time for the work complete in accordance with the drawings and specification, (b) net production in price and time from (a) for furnishing but not installing the feed water heater, storage tank, pumps and certain steam, exhaust, boiler feed and drip piping in connection with the above equipment to the points indicated on the drawings, from H. F. Friedstedt, 327 South La Salle St., Chicago, Ill., (a) $4898 (50 days), (b) $14; Rust Engineering Co., Farmers Bank Bldg., Pittsburgh, Penn., (a) $6840 (30 days), (b) $19.

Minn., Bemidji—The city has awarded the contract for installing pumping systems and building 2 reservoirs, having a capacity of 200,000 gallons, to Layne & Bowler, Chelsea Ave., Memphis, Tenn. Estimated cost, $35,000.

Cal., Los Angeles—The Board of Public Service, 645 South Olive St., has awarded the contract for furnishing sheet steel rivets and pipe section for pipe line and penstocks for power plant No. 2 in San Francisquito Canyon, to the Western Pipe & Steel Co., 1758 North Broadway. Estimated cost, $92,000. Noted Jan. 7.

Cal., San Diego—The San Diego & Arizona Ry. has awarded the contract for the construction of railway shops, including a boiler room, oil room, etc., to Brawner & Hunter, 1444 I St. Estimated cost, $19,527.